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ABSTRACT

Presented is an environmental science interdisciplinary learning program designed for use on the junior high or senior high school level. It includes learning activities coordinated with behavioral objectives as well as an Ecology Game. The program is composed of seven modules, each of which deals with an element of the science of ecology. The modules are subdivided into sequences and units, each addressing specific ecological concepts. The instructional approach employed is founded on the use of process oriented learning activities built around cognitive, psychomotor and affective behavioral objectives. The learning activities include laboratory investigations, role playing, literature research, class field trips, as well as games. (Author/EB)

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Earth's Cycle Of Life: Operational Geosphere StudY

SE 020 976

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ABSTRACT

ECOLOGY is a learning activity package designed for the interdisciplinary teaching of environmental science on the junior and senior high school levels. The program is composed of seven modules each of which deals with an element of the science of ecology. The modules are subdivided into sequences and units, each addressing specific ecological concepts. The instructional approach employed is founded on the use of process oriented learning activities and corresponding behavioral objectives directed toward cognitive, psychomotor and affective learning. The learning activities incorporate a variety of disciplines, and they include laboratory investigations, role playing, literature research, class field trips, as well as an Ecosystem Game.

The program is a very personal one as it reflects both the author's educational and ecological values. It is hoped that its use will lead students to value and respect the ecological balance of nature.

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Working under the guidance of:
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ALTERNATIVE INSTRUCTIONAL METHODS

Alternative Instructional Methods is a list of different teaching methods that can be employed to add variety and motivation to lessons. The descriptive list appears on the following page.

These techniques may be employed as substitutes for various activities presented in this learning package. Several specific activities for which an alternative method can be used have been indicated by the superscript, AIM. Such a superscript refers the reader to the AIM Entries page at the end of this package.

AIM*

*Alternative Instructional Methods

1. Network of Lab Envestigations:

   Two or more different lab projects performed by groups of students simultaneously or sequentially and followed by demonstration to the class of each lab investigation by the student group that performed it.

   The teacher's role here may be as the presentor of an ongoing lecture, a roving group assistant, coordinator, guide, or any combination of these positions.

2. Realia/Demonstration Network:

   Several demonstrations or presentations stationed at specific locations in the room for students to visit sequentially either in groups or individually. This activity should include writing answers to questions found at each station, reporting orally, or recording observations and/or questions.

3. Role Playing and Debate Presentation:

   Students adopt the role of someone in society (concerned citizen, ecologist, economist, government official, etc.) and present the views, attitudes, values and beliefs of this individual based on the research they have done in a debate format.

4. Lecture Presentation with Interspersed Discussions:

   The teacher presents the material of the lesson using a basis lecture approach, but interrupts the presentation with small class discussions of various topics.

5. Open Exploration:

   Students embark on an open-ended investigation of an area of study, directed and guided by their own creativity, interests and curiosity.

6. Team Teaching (Verticle Teaching)

   The teacher invites a fellow teacher to present a lesson. This method can be employed in order to introduce to the class an instructor more knowledgeable about a specific topic or to provide a new approach and perspective to the class.

CREATIVE ECOSYSTEM BULLETIN BOARD

An on-going activity directed to the final representation of the ecosystem upon course completion.

The class is divided into a number of groups, and, by drawing lots, each group is given a Module topic or a Sequence topic to represent. Upon the completion of each Module or Sequence, the teacher meets with the group assigned to that topic to outline with the students the essential elements of the material.

Students in the group then create representations for the concepts of that Unit of study and display their work on a bulletin board designated for that purpose. Students bring their individual talents to the project: Artwork, printing, plant care, collage making, sketching- anything to symbolize the concepts.

The bulletin board is to be a cumulative effort, so that each group adds new material to what has already been done. In this way, the final product will be a class representation of a generalized ecosystem.

MODULE #1 ENERGY

RATIONAL:

If energy is the mediator of change in the environment (and it is), and if change includes every possible "happening" (and it does; for example, change in size, color, structure, texture, and position), then one may conclude that energy is the environmental weapon against all forms of stagnation. Without energy, ecology, the study of the environment, could not exist.

SUGGESTED BOOKS AND REFERENCES:

1. Biology and Society by Andrew McClary: MacMillan Publishing Company, Inc. Collier MacMillan Publishers 1975 pp 10-11 "Entropy".
2. Fundamentals of Ecology by Eugene P. Odum; W.B. Saunders Co., 1971 Chapter #3 "Energy and Thermodynamics".
3. Environmental Science by Amos Turk, Jonathan Turk, Janet T. Wittes, and Robert Wittes; W.B. Saunders Company 1974 Chapter #5 "Energy Resources, Consumption, and Pollution."

UNIT #1 THE SUN:
THE PRIMARY SOURCE OF ENERGY

BEHAVIORAL OBJECTIVES:

1. The student will be able to list at least five examples of the environmental roles of the sun as an energy source presented in the film shown.
2. The student will be able to define, in writing, what is meant by photosynthesis.
3. The student will be able to describe the effect of light on chlorophyll production as seen in the bean plant.
4. Given a list of six descriptive phrases referring to a plant's structure or appearance (for example, "Plant has large green leaves"), the student will be able to select at least three of which are descriptive of a plant grown without light.
5. The student will read one article dealing with the topic "Solar Energy in Today's Society" and be prepared to participate in a seminar by discussing the information he has gathered in his reading. The article may be slected from the list provided or chosen by the student and approved by the instructor.

UNIT #1 (CONTINUED)

LEARNING ACTIVITY #1

Film* and Discussion

List of 16mm films available

1. Energy from the Sun — B & W — 11 min.

   Uses stop-motion photography, animation and dramatization to show that all forms of energy are related to the sun; very detailed coverage.

2. Our Mr. Sun — color — 55 min.

   A dramatic story of the sun and its vital importance to life on Earth by the Bell Telephone Company.

3. Portrait of the Sun — color — 18 min.

   Describes the sun's physical characteristics and how they are investigated through animation and live-action photography.

*All films should be previewed before use.

LEARNING ACTIVITY #2: Lab Experimentation

The Effect of Light on Plant Growth and Development

Adapted from: Laboratory Studies in Biology #732 W.H. Freeman and Company

I. Background:

Photosynthesis is the process by which green plants capture the light energy of the sun in order to produce the food materials they need to survive. Chlorophyll is the essential green pigment that enables plants to perform photosynthesis.

II. Purpose:

To illustrate an example of the effect of light energy from the sun on plant life.

III. Materials needed:

5" pots: soil-filled; Dwarf bean seeds; a dark room

IV. Procedure:

1) Obtain 2 5" pots and make six holes about ½" deep in the soil in each pot.

2) Drop one bean seed in each hole and fill in each hole with soil.

3) Label one pot "light" and the other "dark" and identify your pots with your name.

4) Water each pot.
Place the pot to be kept in the light in the indicated area. Place the pot labelled "dark" in the dark room.

5) After 9-14 days, observe the plants in both pots.
Record your observations of the color of the shoots grown in the light and those grown in the dark.

V. QUESTIONS:

1) What can you say about the presence of chlorophyll in the shoots grown in the dark and those grown in the light?

2) In which of the two environments, light or dark, can photosynthesis occur? Why?

3) Are there any other observable differences in structure or general appearance between the plants grown in the dark and those grown in the light? If so, list them.

LEARNING ACTIVITY #3 Seminar

Topic: Solar Energy in Today's Society

Introduction:

The topic of solar energy in today's society is a multi-faceted one. It involves, for example, aspects of economics, business, physics, biology, culture, and other fields.

This seminar is intended to encompass these various components of the topic, each student becoming involved in the field that most interests him.

Choose an article from the list provided, or bring in another article of your choice for approval. Students are encouraged to present articles they have located, for these articles will be used to update the seminar list for future use.

Seminar Article List

1. Agnew, I. Soviets go after sun's energy; Science Digest 75:88 May 1974.
2. Clark, B. House that runs on the sun; Readers' Digest 104:31-2 + May 1974.
3. Colorado shows how to put sun to work; U.S. News 78:66 June 2, 1975.

4. Commoner, Barry (ed.) Solar energy - bring the sun down to earth; symposium; Harper 248: 3-10+ June 1974.

5. Gwynne, Peter Sun Power; Newsweek 85: 50+ February 24, 1975.

6. Hammond, A.L. Solar energy reconsidered: ERDA sees bright future; Science 189: 538-9 August 15, 1975.

7. Quigg, P.W. Breakthrough in solar energy for the home? Saturday Review World 1: 54 May, 1974.

8. Zeman, T. Solar power now; Ramparts 13: 21-5+ April, 1975.

UNIT #2 ENERGY:

Kinetic vs. Potential

BEHAVIORAL OBJECTIVES:

1. The student will be able to define, in writing, energy, kinetic energy, and potential energy using either the traditional definitions or the alternative definitions discussed in class.

2. The student will be able to describe an example of kinetic energy and an example of potential energy as seen operating in the natural environment (use either living or nonliving elements or both, but not man-made situations, such as dropping a book from a shelf as an example of kinetic energy.)

3. The student will be able to list four forms of energy and indicate if each is potential or kinetic.

LEARNING ACTIVITY

Lecture and Discussion

Part I: Definitions - Compare traditional with non-traditional

A) Energy

traditional: "The Ability to Do Work"
non-traditional: 1) Discuss content of Rationale
2) Energy is both the potential ability to bring about some activity and the actual initiator of activity and the supporter of continued activity.

B) Potential Energy

traditional: "Energy which is stored up in matter"
non-traditional: The Latent ability to bring about some activity.

C) Kinetic Energy:

traditional: "Energy a body has because of its motion"
non-traditional: The energy that initiates a change or activity and which sustains the activity initiated.

Part II Forms of Energy

A) Discuss forms of kinetic energy and give an environmental example of each. For example: mechanical energy ——→ animal and plant movement.

B) Discuss forms of potential energy and give environmental examples. For example: chemical energy——→ food; potential energy in clouds.

c) Discuss if one type of energy is more important than the other. Could life exist without kinetic? Without potential?

UNIT #3 LAWS OF THERMODYNAMICS

BEHAVIORAL OBJECTIVES:

Given the two laws of thermodynamics and a list of five situations, the student will be able to indicate which of the two principles of thermodynamics is in operation in at least three of the five items.

Example:

A cold spoon is placed in a hot cup of coffee. A short while later, when the spoon was touched it was found to be warm.

Given the two laws of thermodynamics, indicate which law(s), if any, are operating here.

Learning Activity:

Lecture and Discussion

Part I: Statement of the Laws and Explanation

A. Definition:

Thermodynamics is the study of heat energy and its relationship to other energy forms, such as mechanical energy.

B. First Law of Thermodynamics:

Energy can be changed from one type to another, that is, potential to kinetic or kinetic to potential, and from one form to another, that is, light to heat, for example, <u>but</u> it can never be created or destroyed. No energy is destroyed in the process of transformation from one form to another.

B. Second Law of Thermodynamics

Energy always flows downhill: from an area of high energy content to one of a lower energy content.

"No process involving energy transformation will spontaneously occur unless there is a degradation of energy from a concentrated form into a dispersed from." (Taken from reference #2).

Important Note on Thermodynamics: Lack of Efficiency

We must admit that at times energy does <u>appear</u> to be lost when a transformation from one form to another occurs. Nevertheless, energy has <u>not</u> been destroyed, rather, some energy has been changed to a form we can not use, namely heat energy - the most dispersed form of energy in our solar system. In other words, energy transformations are not 100% efficient; "Energy can not be completely recycled."

(taken from reference #3)

Example: All of the energy captured by a blade of grass is not converted to usable energy for the grasshopper eating it, rather, some is dispersed as heat energy.

Part IV

Student input of examples of each law.

UNIT #4 Disorder (Entropy) vs. Life

BEHAVIORAL OBJECTIVES

1. The student will be able to define entropy, briefly.
2. The student will be able to describe in writing the relationship between life and entropy.

Learning Activity

A Deductive Exercise

Step #1

Entropy and non-living materials:

a) Put students at increasing distances from energy sources: radiator, light, sound. Have them describe their perceptions - Point out the dispersion process.

b) Throw a handful of jacks on desk top several times. Can a pattern be observed? Point out randomness vs. order.

c) Place drop of food coloring in water. Point out dispersion and contrast with possibility of dispersed colored particles reforming a concentrated drop.

Use dissolving of salt in water as another example.

Step #2

Identify this Disorder as Entropy

Step #3

Organize the principle:

Any isolated non-living system will move toward maximum disorder, randomness or entropy.

Step #4

Discuss growth of an organism:

Take in food to produce body parts. Is this progression toward disorder as was shown above?

Point out movement toward organization in lving things. What happens at death?

Step #5

Build to deduction:

All life creates and maintains a high state of internal order, or a state of low entropy. It is in a constant struggle against entropy.

MODULE #2 MATTER

INTRODUCTORY NOTE:

Although the topics of oxygen, carbon dioxide, and nutrients discussed in this module involve cyclic phenomena within the ecosystem, I have postponed this aspect of their ecological importance until a later module. At that time, all cyclic phenomena will be presented and integrated, so that our environmental study will be experienced as culminating in the balanced, functioning ecosystem.

RATIONAL:

Matter is the substance of all existence: both the living organisms and the non-living material on earth. It is intimately related to energy, for matter is energy's vehicle of expression.

UNIT #1 MATTER: Some Basic Characteristics

BEHAVIORAL OBJECTIVES:

Upon completion of this unit the student will be able to:

1. Briefly define matter.
2. Describe in writing the relationship between energy and matter.
3. List the three states of matter and give three examples of each.
4. Briefly describe in writing what is meant by "the particulate nature of matter."

LEARNING ACTIVITY:

Lecture and Discussion

Part I: Definition

"Matter is anything that takes up space and has weight."

Point out:

Matter is not restricted to what is detectable by the naked senses.

Pose problems:

For example: Is air matter? Why?

Discuss Rationale for Module:

Is it proper to say that matter is anything and everything that can be changed (change defined in Module #1) by Kinetic energy acting on it and which can possess potential energy? If so, then is matter energy's vehicle of expression?

Examples for this concept:

1. Because water can possess potential energy, we have hydro electric power.
2. Heat energy acts on air to produce winds.
3. The warming of soil results from the absorption of heat energy from the sun.

Part II: States of Matter

First determine if students are already acquainted with the topic.

Point out that the three states are all matter: they differ only in form.

Part III: Particulate Nature of Matter: Atoms and Molecules.

Set up analogy with concepts of Geometry:
Geometric concept of a line - composed of "particles", that is, points.

Concept of matter - composed of particles, that is, atoms and molecules.

Contrasting qualities:

1. Geometric points are imaginary.

   Atoms and molecules may seem to be imaginary because they aren't visible to the naked eye, but they are real.

2. There is an infinite number of points composing a line, but there is a definite, finite number of atoms and molecules in any given sample of matter, even in a sample as large as a tree or a mountain.

UNIT #2 OXYGEN AND CARBON DIOXIDE

BEHAVIORAL OBJECTIVES

Upon completion of this unit the student will be able to:

1. Write the chemical equation for photosynthesis and describe, in a brief essay, what the equation symbolizes. Included in the essay will be: the fate of carbon dioxide and of oxygen; how energy is related to the process; the fate of the carbohydrate; what the overall "purpose" of the process is to the organism.

2. Write the chemical equation for respiration and describe, in a brief essay, what the equation symbolizes. Included in the essay will be the same concepts listed above for photosynthesis.

3. Given the combined equation for photosynthesis and respiration, discuss what this representation indicates about the relationship of these two processes.

4. Demonstrate his understanding of the photosynthesis lab conducted in class by stating what aspect of the photosynthetic process it was designed to illustrate and by describing the technique used to identify the product obtained.

5. Describe in writing how brom thymol blue works as a chemical indicator.

6. Explain in writing why brom thymol blue could be used to test for the presence of carbon dioxide produced by elodea in the respiration experiment.

7. Explain in writing the color-change observations obtained in the respiration experiment. This explanation will include: 1) What change, if any, was observed in each type of test tube (experimental-dark; control-dark; experimental-light; control-light). 2) What each color change indicates.

8. Describe in writing the importance of ozone in the atmosphere.

9. Participate in the Ozone Debate by contributing information he has obtained through his various readings on the topic. His presentation should demonstrate a specific point-of-view found operating in this controversy.

10. List at least four facts (economic, legal, ecological, etc.) he has discovered as a result of his readings or of the classroom debate regarding the ozone controversy.

11. Organize and write a personal statement of some opinion, value, attitude, interest, or belief he has developed as a result of the Ozone Debate class experience.

LEARNING ACTIVITIES #1

Lecture and Discussion

Part 1: Oxygen - Basic Characteristics

A. Its symbolic representation as a gas

O_2 - a molecule composed of 2 atoms.

B. In what forms does it appear?

As molecular O_2; in the CO_2 molecule; in the H_2O molecule; in molecules of sugars, starches, proteins, and other forms.

C. Where is it found?

Soil, Water, Atmosphere

Part II: Carbon Dioxide - Basic Characteristics

A. Its symbolic representation

CO_2 - a molecule composed of one atom of carbon and two atoms of oxygen.

B. Where is it found?

Soil, Water, Atmosphere

LEARNING ACTIVITY #2

Lab experiments on photosynthesis and respiration: The inter relationship of O_2 and CO_2 AIM

Background:

1. Photosynthesis

Equation: $CO_2 + H_2O \xrightarrow{\text{light}} C_6H_{12}O_6 + O_2$

Definition: Review Module #1; Unit #

Additional Information: The energy that is captured by green plants from the sun, is used during photosynthesis to combine carbon dioxide and water to form the more complex carbohydrate molecules, symbolized $C_6H_{12}O_6$.
NOTE: Oxygen is produced
Carbon dioxide is consumed

2. Respiration

Equation: $C_6H_{12}O_6 + O_2 \longrightarrow CO_2 + H_2O + \text{Energy}$

Definition: The process by which organisms break down food materials (Note carbohydrate in equation), thereby releasing carbon dioxide and water and, most importantly releasing the energy that was stored in the former complex food molecules.
NOTE: Oxygen is consumed
Carbon Dioxide is produced

3. Relating the processes:

Combined equation: $CO_2 + H_2O \underset{\longleftarrow}{\overset{\text{light}}{\longrightarrow}} C_6H_{12}O_6 + O_2$
Illustrates that life uses CO_2 and O_2 inversely.

Part I Oxygen Production in Photosynthesis*

Purpose:

To illustrate the production of gaseous oxygen by plants during photosynthesis.

Materials needed:

Elodea, 6-inch piece of glass tubing and rubber stopper, short-stemmed funnel; large beaker; ring stand; strong light source.

Procedure:

1. Fill large beaker with water and place in fairly large bunch of Elodea at the bottom.
2. Cover Elodea completely with funnel (stem of funnel must be below surface of water). See figure 2-1A.
3. Submerge glass tube in the water-filled beaker, filling the tube with water, then close one end of the tube with the rubber stopper. Take care to displace all air in the tube with water. See Figure 2-1B.
4. Keeping the tube submerged, cover the stem of the funnel with the water-filled tube.
5. Place the whole apparatus on the ring stand and clamp the tube in place over the funnel. See figure 2-1C.
6. Place the apparatus in strong light.
7. Record observations on the next day.

Questions:

When the tube is partially gas-filled (this may take a few days), test the gas by removing the stopper on the tube and holding a glowing splint at the opening. Note what happens. What is the gas that is present? How did it get there?

Part II Carbon Dioxide Production in Respiration*

Background:

The presence of carbon-dioxide will be shown using an indicator called brom thymol blue. In a basic solution, this indicator is blue, but in acid solution it turns yellow.

Carbon dioxide reacts with water to form carbonic acid. What color should the indicator brom thymol blue be if carbon dioxide has been introduced into water?

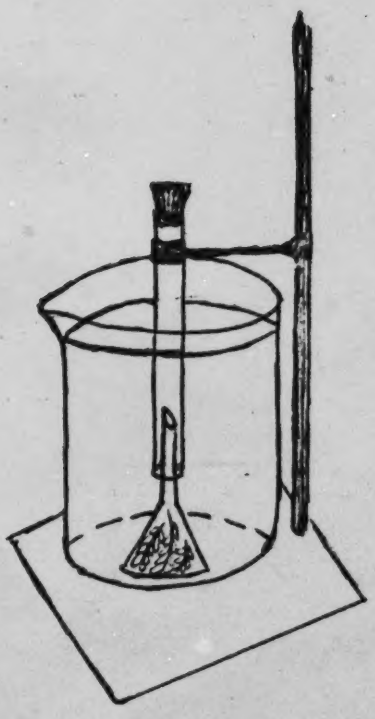
Purpose:

To demonstrate the release of carbon dioxide through the process of respiration.

In addition, to reinforce the fact that respiration is not a process restricted to animals, but, instead, this energy-releasing mechanism is also performed by plants.

A.

B.



C.

Figure 2-1 Apparatus for determining Oxygen Production in Photosynthesis

Materials:

Elodea; Eight 6-inch test tubes; two test tube racks; brom thymol blue solution*; ammonium hydroxide**; aquarium water

* prepare solution by dissolving 0.5 gm of brom thymol blue in 50 ml of water.
** add a trace amount of NH_4OH to brom thymol blue solution, so that solution turns deep blue - this would require about one drop of ammonium hydroxide per liter of indicator solution.

Procedure:

1. Mix 50 ml of aquarium water with 20 ml of brom thymol blue solution.

2. Using this solution, fill eight of the test tubes provided to within one inch from the top.

3. Add a bunch of Elodea to four of these test tubes. This is your experimental group. Do not add anything to the other four tubes; these are your controls.

4. Place two experimental tubes (ones with Elodea) and two control tubes in the dark.

   Place the other four tubes (two experimental; two control) in a sun-lit area.

5. Make observations at the end of lab period and the next day, if necessary.

Question:

Note which tubes, if any, showed a color change and what the change was.

How can you explain your observations in terms of respiration?

*Labs are adapted from:

Biology Investigations by Otto, Towle, and Crider; Holt, Rinehart, and Winston, Inc. 1965. Lab #6-2 A part 2; Lab #7-1, A part 1.

LEARNING ACTIVITY #3

Ozone - Aerosol Debate

Background:

Ozone chemical symbol: O_3 - Composed of three oxygen atoms arranged in a triangle.

It is a very reactive molecule and reacts vigorously with many materials on the earth. Therefore it is found only in the high stratosphere - the ozone blanket.

How ozone layer formed:

Ozone is formed from oxygen, so it first appeared only after photosynthesis began on earth in the primitive seas.

Importance of ozone layer:

As absorbing blanket of ultraviolet light of the sun. U-V light poses dangerous threat to living cells exposed to it on the earth. Therefore, the ozone blanket is an important protector of terrestrial life.

Reference:

The Closing Circle by Barry Commoner: Bantam Books, Inc. 1972 pp.16; 26-27

Organizing the Debate:

Have students each choose a role or occupation to represent in the debate: business executive, economist, ecologist, chemist, lay person, etc.. Each student will present information in the debate using the point-of-view chosen. His material should be obtained from various readings on the ozone-aerosol controversy.

A suggested list of readings, such as the one presented here*, can be provided, but students are also encouraged to use materials they themselves have found.

*Sample Reading List - All articles should be previewed:

1. "Earth's Security Blanket 13 mi. UP" Environmental Science and Technology 9:196 March 1975
2. "Ozone-aerosol Story" Pest Control 43:18 March 1975
3. "Aerosols and Ozone Layer" Changing Times 29:19 August 1975
4. "Doomsday Sprays" M. Roberts New Republic 173: 7-9 August 9, 1975
5. "High Altitude Data Conform Ozone Theory" Science News 108:84 August 9, 1975
6. "What We Know - And Don't Know - About The Ozone Shield" T. Alexander Fortune 92:184-8+ August, 1975

UNIT #3 CHEMICALS IN THE SUBSTRATE

BEHAVIORAL OBJECTIVES

Upon completion of this unit the student will be able to:

1. List the chemical substances that were found to be present in the soil and water samples analyzed in class with the test kits provided.

2. Define, in writing, what is meant by organic pollution and describe briefly, an example of it.

3. Take part in collecting, compiling, and organizing data on an example of organic pollution as a member of a substrate-pollution investigation group.

4. Describe in a brief essay, the highlights of his group's investigation of a form of organic pollution, that is: Where this pollution occurs, what it effects in the environment, the sources of the pollution, and related economic, social, and legal actions or implications.

5. Using the knowledge he has obtained through readings, group discussions, audio-visual materials, and other sources made available to the class make some prediction(s) about the future of the example of organic pollution he investigated. For example, are there signs of improvement; if so, what are they?

LEARNING ACTIVITY #1

Chemical Analysis of Substrate: Soil and Water Testing

Each student is requested to bring to class a water or soil sample from a specific location; for example: tap water, pond water, ocean water, vegetable garden soil, lawn soil, soil surrounding a pond etc.

Each student tests a specific sample of soil or water using the materials in a test kit and records results.

Discussion:

Compare results for the various samples with the whole class. Discuss any variations observed.

Summarize by listing the important nutrients found in general in the two substrates, water and soil.

LEARNING ACTIVITY #2

Class Project: Man's Interference in the Substrate - Organic Pollution

Definition:

Organic pollution - is caused by the introduction of organic wastes, which are actually substances normally found in the environment. However, disruption of the environment occurs because of the increase in amount of these substances or because of the rapid rate of introduction of them.

Class Project: Organize class field trips and/or guest speakers on the topic of pollution due to organic wastes in soil and water.

Divide students into a few groups, each group assigned as investigators for one example of substrate pollution to be dealt with by guest speaker or during field trip. The group should prepare a fact sheet on the causes of the pollution; where it occurs; its environmental effects; future outlook for the situation; proposed methods for eliminating the problem - including students' own creative ideas; government actions being taken or proposed; any ramifications for immediate locality.

Arrange for school newspaper to interview each student group and feature an article based on the reports given. If this is not possible, prepare a class Pollution Newsletter reporting their findings. Mimeograph the report and make it available to the general school population perhaps via homeroom bulletin boards.

Supplementary Resource Materials*:

A) Audio-Visual

1. "Land Pollution" (Filmstrip) Ward's National Science Establishment, 1970. 74 frames, color, 35mm.
2. "Earth, Water, Air" (Motion Picture) Dames & Moore, 1972. Made by Nye Communications Enterprises 29 min, sound color, 16mm.
3. "Pollution: our waters" (Filmstrip) Coronet Instructional Films, 1972. 49 frames, color, 35mm.
4. "Pollution Control" (Filmstrip) Ward's Natural Science Establishment, 1970. 61 frames, color, 35mm.

B) Text Readings

1. Ecology by Eugene P. Odum, Holt, Rinehart and Winston, Inc. 1963, pg. 75.
2. Biology and Society by Andrew McClary, MacMillan Publishing Co., Inc. 1975, pp 118; 120-123.
3. The Economics of Environmental Protection by Donald N. Thompson, Winthrop Publishers, Inc. 1973.
4. The Pollution Reader by Anthony DeVos, Norman Pearson, P.L. Silveston, and W. R. Drynan, Harvest House Ltd., 1968.
5. Man and His Environment: Waste by Wesley Marx, Harper & Row 1971
6. Environmental Pollution, A survey emphasizing Physical and Chemical Principles, by Laurent Hodges, Holt, Rinehart & Winston, Inc. 1973.
7. Environmental Science by Amos Turk, Jonathan Turk, Janet T. Whittes, Robert Wittes, W. B. Sauders Company 1974.

C) Suggested Topics for Periodical Research:

1. Pollution: control, economic aspects, laws & legislation, physiological effects
2. Water Pollution
3. Marine Pollution
4. Soil Pollution

* All materials should be reviewed before using.

MODULE #3: THE ENVIRONMENT: PHYSICAL PHENOMENA

RATIONAL:

To a true environmentalist the question, "Whether to study weather?", would never occur.

For temperature, humidity, light, and wind which collectively determine weather, are the physical phenomena that come to bear on both aquatic and terrestrial environments.

SUGGESTED BOOKS AND REFERENCES:

1. Kahill, W.M. and Frey, J.K., Environments in Profile, Canfield Press, 1973.
2. Storer, J.H., The Web of Life, The New American Library, Inc., 1953.

UNIT #1: EXPLORING WEATHER

BEHAVIORAL OBJECTIVES:

Upon completion of this unit the student will be able to...

1. State, in writing, the three physical principles fundamental to the understanding of weather phenomena which were studies in the class investigation.

2. Describe, in writing, how each of these principles operates in weather phenomena.

LEARNING ACTIVITY: Investigating Weather Principles: Experimentation and Deduction

Divide students into three investigative teams. Each team is to be given written instructions and equipment for doing one of the assigned investigations. (Since some time must elapse between the establishment of the experimental set-up and the observation of results, some supplementary activities should also be planned.)

When each team has completed its activities and formulated a descriptive principle, all students should form a class discussion group in which each team presents the principle it has formulated and, together with the teacher, establishes how the principle functions in weather phenomena.

Team #1:

-Materials Needed:

2 shallow metal pans, labelled A and B and having their outer surfaces covered with black paper.
A graduated cylinder.
Heat lamp.

-Directions:

1. Measure, using the graduated cylinder, 20 ml of water and pour the water into pan A.
Do the same for pan B.
2. Turn on the heat lamp and orient pan A so that its black outer surface is in the path of the lamp's rays. The pan should be approximately 6 inches away from the lamp.
Position pan B in an area that does not receive the lamp's rays.
3. Allow the pans to remain where positioned for about 45 minutes.
4. After this time has passed, carefully pour the water from pan A into the graduated cylinder and record the volume of water present. Empty the graduated cylinder.
Carefully pour the water from pan B into the graduated cylinder. Again, record the volume present.

-Assignment:

Formulate a statement in which you propose a principle you believe to have been demonstrated by this experiment.

Team #2

-Materials needed:

Terrarium containing a green plant, recently watered.
Strong desk lamp.

-Directions:

1. Place the terrarium in front of the desk lamp and turn on the light. Direct the lamp so that the light is shining on the soil.

Allow the apparatus to be set up for about 45 minutes.

2. Upon returning to the apparatus, answer the following questions among yourselves: they will help you with your assignment.

1) Place your hand in front of the light and then on the sides of the terrarium. What do you expect is happening to the air in the terrarium?

2) Shut the light off. How will this affect the ari temperature?

3) Observe the insides of the walls of the terrarium after a few minutes. Run your fingers along the inside of one of its walls. What has happened?

-Assignment:

Formulate a statement in which you propose a principle you believe to have been demonstrated by this experiment.

Team #3

-Materials needed:

Helium filled balloon (For this experiment, let helium represent air.)
Masking tape.
Heat lamp.

-Directions:

1. Balance the helium balloon so that it will remain floating at a fexed level by applying masking tape to the knot at the end of the balloon.

2. Holding the heat lamp about 6" to 8" away from the balloon, direct the lamp rays at the balloon.

What happens?

3. Remove the lamp from the direction of the balloon. Then what happens?

-Assignment:

Using the helium to represent air, formulate a statement in which you propose a principle you believe to have been demonstrated by this experiment.

PRINCIPLES TO BE DISCOVERED:

Team #1:

When the water absorbs energy in the form of heat, and its temperature is raised above a certain degree, it turns to vapor.

Application to Weather:

Water vapor in the air is carried by wind.

Team #2:

Warm air holds more water vapor than cold air, therefore, when air containing water vapor is cooled, some water vapor precipitates as fine water droplets.

Special notes: In this discussion point out that the air is warmed not directly, but rather by contact with the warmed dark surfaces of earth. Also note that the sources of the water are evaporation from soil and photosynthesis.

Relate this principle to principle #1:

The water vapor carrying capacity demonstrated by team #1 is dependent upon the temperature of the air.

Application to Weather:

The formation of clouds and, under certain conditions, rain and snow.

Team #3:

Warm air rises while cold air sinks. As air is warmed it expands and becomes lighter, therefore it rises, while cooler air is heavier and sinks to the surface to replace the warmer air.

For Discussion: Application to Weather

This fact has implications in the circulation of air: Warmed air rises from the earth's surface, is cooled in the atmosphere above only to sink to the surface and again be warmed. This is one of the causative factors of wind.

Relate this concept to principles #1 and #2: Water vapor gets circulated along with air and the cooling vapor in the air results in cloud formation, rain, and snow.

UNIT #2: METEOROLOGY

BEHAVIORAL OBJECTIVES:

Upon completion of this unit the student will be able to...

1. Use a weather observation instrument and obtain accurate results.

2. Define in writing thermocline.

3. Label the area of a given depth/temperature curve that represents a thermocline.

4. Define in writing epilimnion and hypolimnion.

5. Label the area of a given depth/temperature curve that represents the epilimnion and th area that represents the hypolimnion.

6. Describe three examples of biological phenomena affected or determined by weather conditions.

LEARNING ACTIVITY #1: Observing and Recording Weather Phenomena AIM

-Have students engage in several of the following activities, individually or in groups. The activity should consist of:

a) Researching the principles of operation of the equipment to be built and/or the phenomena to be observed;
b) Constructing (where applicable) and operating the tool of observation;
c) Recording observations of the weather phenomena.

1. Make a Barometer:

Suggested reference: Brown, M.F. and others, Laboratory Investigations in Earth Science, pp. 89-91.

2. Measure Rainfall:

Collect water using a straight-sided can. Based on the volume collected during the rainfall, determine the amount of rain that fell on a square mile.

3. Make a Wind Gauge:

Suggested reference: Brown, M.F. and others, Laboratory Investigations in Earth Science, pp. 93-94.

4. Measure the size of raindrops:

   Suggested reference: Blanchard, D.C., From Raindrops to Volcanoes, pp. 4-8.

5. Using clear plastic food wrap, cover a T.V. screen and trace the weather maps with a felt-tipped marker. By doing this every day for one week or more, one can observe the progression of weather fronts.

6. Take color photographs of the sky just after the sun has set for a period of one or more weeks. Study newspaper weather maps for this period and compare them with the photographs taken.

LEARNING ACTIVITY #2: Guest Speaker

Invite a meteorologist from local T.V. stations to visit the class as a guest speaker.

If possible, have students set up a display of their projects from learning activity #1 and have an informal demonstration or presentation of reports students have prepared.

LEARNING ACTIVITY #3: Weather and the Substrate: Temperature Effect on Lake Water

Laboratory Investigation:*

Generating a Thermocline

Background:

Standing freshwater forms layers of different temperatures. This gradation of temperatures consists of an upper warm layer which is heated by the sun and as a result is composed of expanded, lighter water, and, with increasing depth, colder and colder layers of water. The warmer surface water is called the epilimnion and the cooler, low-lying water is called the hypolimnion. The zone between the epilimnion and the hypolimnion is called the thermocline. This zone is composed of waters of rapidly dropping temperature and usually forms a barrier to water circulation between the epilimnion and the hypolimnion.

This thermocline remains stable throughout the summer, but autumn marks the advent of water mixing which is completed by the winter season.

Water layers have important biological implications, for species of organisms orient themselves in a water layer according to their optimum temperatures.

-Materials Needed:

- Water-filled aquarium
- Heater
- Thermometer
- Food Coloring

Procedure:

1. Place the aquarium heater in the water-filled tank. Do not introduce any devices that cause agitation of the water such as filters or bubblers.

2. Measure the temperature system established by slowly lowering a thermometer into the water and recording the temperature in degrees centigrade at 3.0 cm intervals.

3. To visually demonstrate the existence of the epilimnion and the hypolimnion, carefully place some food coloring into the water of the aquarium.

While the upper water layer will become colored, the lower hypolimnion will remain clear because of the thermal barrier established by the thermocline.

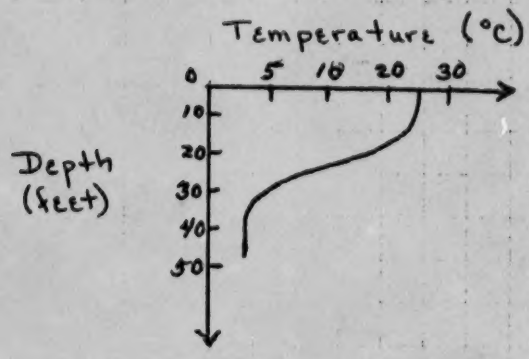
4. Using the data obtained in step #2 above, prepare a graph like figure 3.1. Label the epilimnion, the hypolimnion and the area of the thermocline.

LEARNING ACTIVITY #3: Weather Effects on Biological Organisms
Field Trip

Class Trip to Woodshole (or a museum of life sciences); Have students gather information on how changes in temperatures, water clarity and turbidity, and other factors affect biological organisms and their life cycles.

*Adapted from Environments in Profile by W.M. Kaill and J.K. Frey, Canfield Press, 1973, pp. 20-22; 39.

Figure 3.1 Depth/Temperature Curve*



In first 15 feet, the water is very warm (epilimnion). From 15 to 35 feet (thermocline), the water changes from 24° to 4° C. Below the thermocline, water is cold (hypolimnion).

* Taken from: Environments in Profile, by W. M. Kaill and J. K. Frey, Canfield Press 1958, pg. 38.

MODULE #4 THE ORGANISM-ENVIRONMENT RELATIONSHIP

SEQUENCE A Reciprocity of the Organism-Environment Relationship

RATIONALE:

The investigation of the Organism-Environment Relationship is a two-fold endeavor, for these ecological entities are interdependent. Not only is every living creature sensitive to and responsive to its environment, but also it actively modifies the locality it inhabits.

REFERENCES:

1. Turk, Amos, and others, Environmental Science, W.B. Sauders Co. 1974.
2. McClary, Andrew, Biology and Society, MacMillan Publishing Co., Inc. 1975.
3. Storer, J. H., The Web of Life The New American Library, Inc. 1953.
4. Barnes, R. D., Invertebrate Zoology, W. B. Saunders Co., 1974.
5. Odum, E. P., Ecology, Holt, Rinehart and Winston 1963.
6. Odum, E. P., Fundamentals of Ecology, W. B. Saunders Co., 1971.

UNIT #1 Adaptation: The Organism Responds

BEHAVIORAL OBJECTIVES

Upon completion of the unit the student will be able to:

1. Define in writing: gene, gene pool, adaptation and natural selection.
2. Compare and contrast in a brief essay genetic adaptation and behavioral adaptation.
3. Given a list of structural or behavioral descriptions of organisms, indicate whether the situation described is an example of genetic or behavioral adaptation.
4. Compareand contrast in a brief essay behavioral adaptation resulting from physiological potential and behavioral adaptation resulting from learning.
5. List two examples of each form of adaptation: genetic adaptation, behavioral adaptation based on physiological potential and behavioral adaptation based on learning. These examples may be those presented in the classroom presentations or other examples the student has discovered through his other learning activities.
6. Prepare a written report of observations made during the class field trip to the rocky seashore. Included in a report will be: 1) The various organisms, plant or animal, found there and 2) The adaptations these organisms demonstrate which enhance their survival in this habitat along with the environmental aspect involved in this adaptation.
7. Discuss orally or in written form an example of an organism's adaptation(s) to some aspect of weather or climate which the student has chosen to investigate. The discussion should include the weather or climate feature concerned, the organism involved and its specific adaptation, a description of the adaptation as genetic or behavioral, and the source(s) used to research the topic.
8. Given a written description statement of a specific example of environmental changes and an organism existing in that environment, formulate a hypothetical design for the adaptation(s) of the organism which might occur and state his reasons for postulating the adaptation(s).

LEARNING ACTIVITY #1 Adaptation:

Lecture Presentation and Network of Lab Demonstrations

1. Introduce topic - present definitions:

Adaptation - the adjustment made by an organism or a group of organisms to a change in the environment;
- "coping with a changing environment"

Some fundamentals to define:

gne, gene pool, genetic mutation, natural selection

2. Discuss Figure #4.1 using it as transparency with overhead projector.

A. Terms used in scheme:

Genetic Adaptation - mechanism of adptation based on the chance appearance in an organism of an alteration of its genetic makeup which proves to help the organism cope with an environmental change.

Behavioral Adaptation - mechanism of adaptation in which an organism exhibits some physiological change (such as change of color, position, or body function) which does not involve a genetic alteration, but which reflects instead the physiological capabilities possessed by the organism.
- "via physiological potential" - behavioral adaptation confined to and limited by the physical capabilities of the organism.
- "via learning" - behavioral adaptation in which previously acquired knowledge operates on an organism's physiological potential to affect the adjustment.

B. The structure of the scheme.

Genetic Adaptation is placed at the foundation level of the scheme since it is the genetic makeup of an organism which determines its physiological potential

Behavioral Adaptation via Physiological Potential is shown as supporting the "via learning" category since the latter exists within the realm of physiological potential. In fact, learning represents an advancement within the physiological mechanism of adjustment.

Center Boxes: Indicate the causative factor of the adaptation
Left-hand Boxes: Indicate the Level of Life involved.
Right-hand Boxes: Indicate the Extent of Adaptive Influence

- Special Note: Top right hand box:
"Man and Culture":
Learning acquired by a human being during his life time can be transmitted in the form of culture to his offspring. This process may be considered as psuedo-inheritance. - This concept will be expanded upon in the final module of this learning package.

3. Network of Lab Demonstrations

Set up several demonstrations of behavioral and genetic adaptations using both preserved and live specimens. Each demonstration center should include index

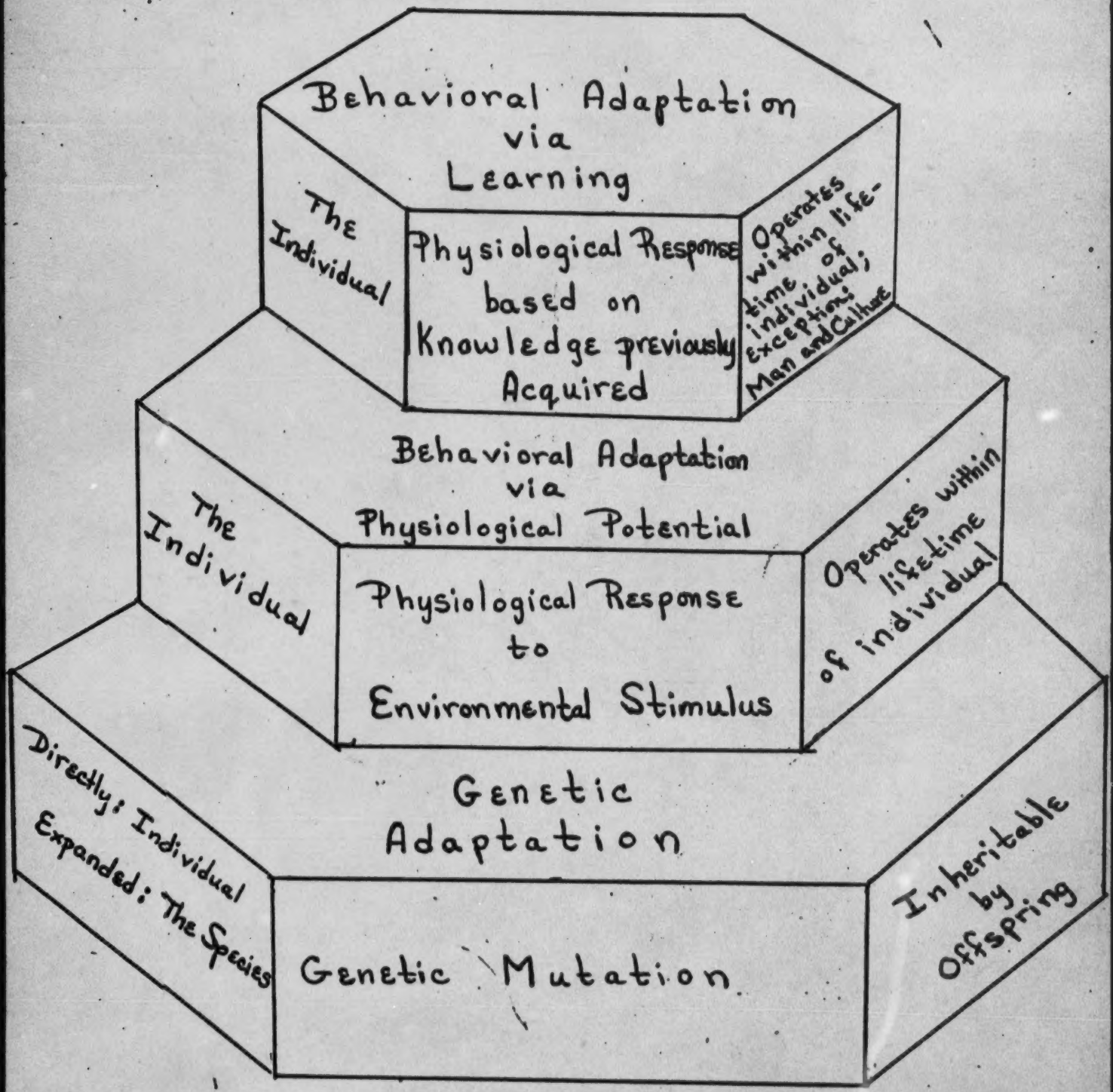


Figure 4.1 Adaptation Scheme

cards bearing information, directions and questions pertinent to that station. In each case the student should be able to identify the particular mechanism of adaptation illustrated.

Examples:

A. Behavioral Adaptation via Physiological Potential:

Cover a small plant with a cardboard box that has an opening that has been cut out of one side. Allow sunlight or lamplight to pass through this opening, and after a few days have students observe the plant's growth and explain the form of adaptation illustrated by the growth of the plant (that is, its bending toward the light).

B. Behavioral Adaptation via Learning:

Train a rat to run a maze for food. Have students contrast this mechanism of adaptation with the other two forms.

Similarly, students could bring to class their own pets which have been trained to perform tricks or obey commands. Discuss this as an example of adaptation due to learning.

C. Genetic Adaptation:

Use Replica Plating Technique to demonstrate the existence of mutant bacteria which are resistant to antibiotics. See Microbiology by Philip L. Carpenter, W. B. Saunders Company 1972 pp. 188-189.

Resources:

1. Environmental Science, Amos Turk, et al, Chapter #2 Human Adaptation to Environmental Change.
2. Biology and Society, Andrew McClary, Chapter #2 "Life and Evolution" Chapter #6 pp.64-65 Physiological Adaptability.

LEARNING ACTIVITY #2 Field Trip to Rocky Seashore

Instruct students to observe and collect data on the differnt organisms peculiar to this habitat and the adaptations they demonstrate which enable their existence in this environment. Organisms studied should include barnacles, mussels, limpets and plant-life along with their adaptations.

REFERENCE:

Biology and Society by A. McClary, MacMillan Publishing Co., Inc. 1975 pp. 17-19.

LEARNING ACTIVITY #3 Adaptation to Weather and Climate

Students select and investigate an example of an organism's adaptation to weather or climate. Resource material may include various text materials as well as recent periodical publications and audiovisual materials. Report format may be either written, oral or a combination of the two, and students may also choose to present demonstrations, specimens, diagrams or drawings. A student might also supplement his report by inviting a guest speaker for the class.

LEARNING ACTIVITY #4 Hypothetical Adaptive Design

Prepare a few packets of descriptive cards outlining environmental changes encountered by an organism in a specific situation. The descriptive information provided should include: 1) Pertinent characteristics of the organism involved; 2) The state of the environment before the change; 3) The nature of the environmental change and the resultant state of the habitat.

Students are to use this information and, by employing the knowledge of the nature of adaptation the have developed by progressing through the unit, construct a hypothetical design for the adaptation of the organism to the environmental change cited. Reasons for his "educated guess' should also be provided.

Sample: Industrial Melanism - taken from Biology and Society by Andrew McClary pp. 26-28

Information Given:

1) Organism - Peppered moth; light grey-color; nocturnal organism: active at night, rested on trees during day.
2) Environment before change - Midlands of England; trees'bark covered with light colored lichens.
3) Environmental change and resultant state of habitat: Industrial revolution; cities poured pollution into atmosphere such as coal smoke and soot.

Students could hypothesize that as the soot blackened trees, any dark-colored mutant moths would have adaptive advantage over light-colored ones for they would be concealed by color-camoflauge from prey whereas the light-colored moths would be easily spotted by predators.

Sources of other examples of adaptation:

1. Environmental Science, Amos Turk, et al., Chapter #3
2. Biology and Society, Andrew McClary, Chapters #2, 3, 4, 5 and 6.

UNIT #2 Succession: The Result of an Organism's Environmental Impact

BEHAVIORAL OBJECTIVES

Upon completion of the unit the student will be able to:

1. Explain in a brief essay what is meant by the statement, "An organism actively modifies the locality it inhabits."
2. Describe verbally, with the aide of visual materials if he so desires, an example of how a particular organism alters its environment.
3. State in writing the principle of succession.
4. Submit a written report listing and describing the examples of the principle of succession found in the chapter "The Forest Grows" of John H. Storer's The Web of Life.
5. Take part in the creation and maintenance of the class investigation of a hay infusion culture model of succession.
6. Physically demonstrate the law of succession by participating in the class endeavor of positively affecting its environment through a collection project.

LEARNING ACTIVITY #1 Lecture and Discussion: AIM

How Organisms Affect Their Environment

1. To initiate discussion and to stimulate thought, the teacher might encourage students to try to refute this concept. Perhaps students will want to try to find references supporting their stand.

2. Discuss specific examples, such as:

   A) The way an earthworm alters its soil environment:

      Soil drainage and aeration and soil mixing and churning.

      Have student set up a demonstration of soil churning by earthworms (Taken from Invertebrate Zoology Robert D. Barnes, Ph.D. pg. 300):

      1) Fill the bottom half of a container with 500 cc of sand.
      2) Fill the upper half of the container with 500 cc of potting soil.
      3) Introduce 5 earthworms into the system.

      Anticipated Results:

      The soil will be completely mixed within a period of several months.

   B) Have students hypothesize the effect of plants on our atmosphere via photosynthesis: Oxygen production.

      Discuss the evolutionary importance of the alteration of the primitive atmosphere due to oxygen production by autotrophs: the creation of a habitat hospitable to heterotrophs.

   C) The nature of soil composition discuss the importance of:

      1) The organic matter contributed to the soil through the decay of plants and animals.
      2) The contribution of the living plants and animals inhabiting the subtrate.

D) Organisms affecting aquatic environments: Study the formation of coral reefs.

REFERENCES:

Invertebrate Zoology, Robert D. Barnes, Ph. D. pp. 130-134.
Fundamentals of Ecology, E. P. Odum, pp. 344-349.

LEARNING ACTIVITY #2 Homework Assignments: Investigating Succession

Introduction:

Present the principle of succession:

As organisms affect and alter their environment, they create conditions more suited to the establishment of new species which do, in fact, come to displace the original occupants of that location.

Assignments:

Students are asked to read Chapter #7, "The Forest Grows" (pp. 40-44) of John H. Storer's The Web of Life and to submit a report in which they list and describe the manifestations of the principle of succession they find in this reading.

LEARNING ACTIVITY #3 A Model of Succession

Project to be studied for a period of about one month.

Demonstrates the early stages of succession as it occurs upon the dumping of organic wastes into a pond or stream. Remind students of their former study of organic pollution.

Adapted from Ecology by E. P. Odum pp. 80 & 81

Procedure:

Have students set up the culture and share in making observations. Upon completion of the study, results should be compiled by the students and instructor to obtain a holistic view of the demonstration.

1) Boil a quantity of dried hay and allow the solution to stand for a few days. By the end of this period, a culture of heterotropis bacteria will have developed.
2) To the hay invusion add some pond water containing seed stocks of various small animals.
   - Observe the succession of organisms that occurs for about one month.
   - Usual sequence observed:
     First to appear: Monads (small flagellates)
     Quickly followed by: Ciliated Prokozoans (such as Colpoda and Paramecium)
     More slowly: Peaks in numbers of specialized ciliates (for examples Hypotricka and Vorticella), Amoeba or Rotifers.
   - After about 90 days the culture will run down as organisms succumb to the lack of food.

LEARNING ACTIVITY #4 Class Activity: How Man Determines His Environment

- Point out to students that man can go one step beyond other animals by consciously, willfully (sometimes carelessly) affecting his environment.

  To illustrate man's modifications of the environment, one might study his harmful effects such as pollution. However, a more positive approach at this point in the learning experience might prove to be exciting to the student and beneficial to the school or general community.

- Suggest to students that the class perform some community activity designed to consist of a conscious, beneficial interaction on their part with the environment.

  It would also be hoped that an expanded form of the principle of succession might be proposed to the students and employed, that is, that the students would so affect their environment so as to alter the thinking or behavior of both students and citizens who are or will be living in this environment.

- The specific nature of the project, where it is to be conducted, and the format of records or reports to be kept could be determined jointly by the students and the teacher. The students would first investigate possibilities of activities as groups and then discuss the possibilities with the whole class. This form of open exploration would hopefully lead to the identification of problems or community needs that the students believe are relevant and pressing.

POSSIBLE PROJECTS:

Informing the public of environmental concerns: Establishing a method of controlling littering on school grounds; A clean-up project; Interacting with various levels of governmental officials in an area of environmental concern.

MODULE #4 THE ORGANISM - ENVIRONMENT RELATIONSHIP

SEQUENCE B: Population Size: The Determining Factors

Rationale:

The Organism-Environment Relationship encompasses the area of population growth. The proper functioning of this relationship enables the attainment of a population size somewhere between infinity (owing to the reproductive potential of an organism) and non-existance or extinction (which could be produced by certain environmental factors).

UNIT #1 Reproductive Potentials - Approximating Infinity!

Behavioral Objectives:

Upon completion of this unit the student will be able to:

1. State, in writing, the law of multiplication.
2. In a brief written statement, contrast exponential (or geometric) and arithmetic progressions.
3. Given a set of five mathematical progressions, correctly identify each progression as an exponential or an arithmetic one.
4. Explain, in writing, how cell division relates to the concept of mathematical progression.
5. Explain, in writing the significance of exponential progression with respect to the law of multiplication.

References:

1. Reid K. Lauwreys, J.A., Joffe, J., and Tucker, A., Man, Nature and Ecology, Doubleday and Company Inc. 1974, pp. 303-327; 400-404.

2. Farb, Peter and the Editors of Life, Ecology, Time, Inc., 1963, pp 141-144.,

3. Kormondy, E.J , Concepts of Ecology, Prentice-Hall, Inc., 1969, pp. 62-69.

4. Odum, E.P., Ecology Holt, Rinehart and Winston, Inc., 1968, pp. 90-93.

5. Sherman, I. W., and Sherman, V. G., Biology A Human Approach, New York Oxford University Press, 1975 pp. 492-504

LEARNING ACTIVITY #1 Lecture Presentation and Discussion

Present Law of Multiplication:

Organisms have fantastic powers of reproduction which enable them to compensate for large losses in numbers brought about by environmental hazards. (The Web of Life by J. H. Storer p.76).

Analysis of a Case Study:

Reproduction Potential of the Common Housefly Table 4.1*

Method of Presentation:

Prepare Table 4.1 as a transparency to be used on an overhead projector. Using masks, reveal sequentially the population of each generation after initially demonstrating the mathematical calculations involved in the first few generations.

*Taken from Kormondy, E. J. Concepts of Ecology p.62.

LEARNING ACTIVITY #2 Student Exercises

1. Have some students count the number of seeds in a pea pod. Assuming that each seed will produce a plant upon cultivation, how many plants would be produced from the contents of this pod.

Exercises:

1a) If each of these plants produces, in turn, one pod having the same number of seeds as the pod examined, how many plants will be in the second generation?

Generation	Total Population		
	If all survive but 1 Generation	If all survive one year but Produce only Once	If all survive one year and all Females Produce Each Generation
1	120	120	120
2	7200	7320	7320
3	432,000	439,320	446, 520
4	25,920,000	26,359,320	27,237,720
5	1,555,200,000	1,581,559,320	1,661,500,920
6	93,312,000,000	94,893,559,320	101,351,520,120
7	5,598,720,000,000	5,693,613,559,320	6,182,442,727,320

Table 4.1 *.

Production of Houseflies (Musca domestica) in One Year on the Assumptions that a female lays 120 eggs per Generation, that Half of these Eggs (60 eggs per generation) Develop into Females, and that there are Seven Generations per year.

1b) Based on the same conditions as to part a), how many plants can be expected in the following year?

2) Follow the same procedures as in exercise one, assuming that each plant produces two, instead of one, pod.

Questions:

- What does this exercise indicate in terms of reproductive powers?
- Do such results actually occur in nature. Offer some explanations.

2. Have other students study a dandelion ripe with seeds.

Exercises:

1) Make a rough estimate of the number of seeds present on this flower.

2) Given that there are 3 such dandelions per square foot in an open field having an area of 100 square feet, estimate the number of seeds produced by the dandelions in this field.

Questions:

- What implications about reproductive pwoers are demonstrated by this exercise?

- Are these numbers realized in nature? Explain

LEARNING ACTIVITY #3: Mathematical Investigation:

What do we mean by "Fantastic Reproductive Powers"?

Compare and contrast:

Geometric and Arithmetic Progressions AIM

Geometric or Exponential Progression

Stepwise increases consist of the doubling of the numbers present. For example, 2 - 4 - 8 - 16 - 32 - 64, etc.

Arithmetic Progression

Stepwise increases by a fixed amount. For example, 2 - 4 - 6 - 8 - 10 - 12, etc.

Refer to Graphs of Figure 4.2 and use this approach to address the question: "Are we exagerating when we say reproductive potentials approximate infinity?"

1) Have students determine the slope of the graph produced by the arithmetic progression. (Figure 4.2A)
2) Have students determine the slopes of lines *that might be drawn between each consecutive pair of labelled points of the graph of the geometric progression shown. Slopes to be determined: (Figure 4.2B)

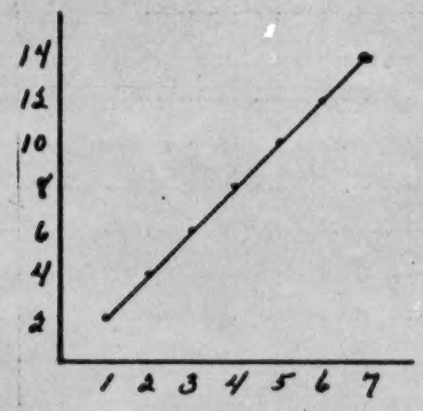
slope $\overline{AB} = \frac{\Delta y}{\Delta x} = \frac{4-2}{2-1} = 2$

slope $\overline{BC} = \frac{8-4}{3-2} = 4$

slope $\overline{CD} = \frac{16-8}{4-3} = 8$

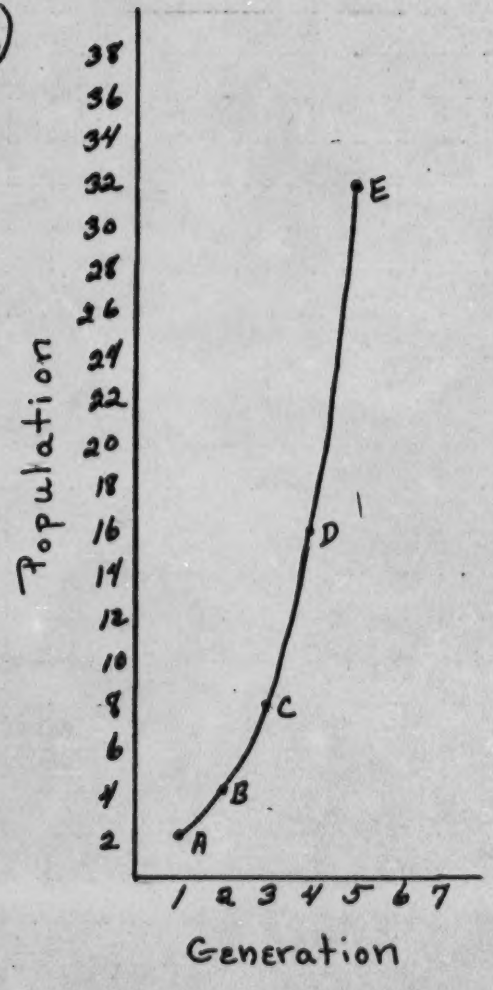
slope $\overline{DE} = \frac{32-16}{5-4} = 16$

A.)



An Arithmetic Progression

B.)



A Geometric Progression

Figure 4.2

* If students have had some introductory training in calculus, this investigation might be approached in terms of the slopes of tangents to the curve.

Questions and Discussions:

1. Students should postulate the results of taking more and more slopes along the graph of the exponential progression.

2. Students should discuss the implications of the slopes obtained from the geometrical and arithmetic progressions.

3. The class should discuss the meaning of the geometric progressions with respect to the growth of populations.

LEARNING ACTIVITY #4: Concrete Demonstrations of Exponential Progressions

One or more of the following activities may be employed to acquaint students with concrete examples of exponential progressions.

#1 Have students fold a paper in half, then in half again and so on, recording, after each folding, the number of rectangular regions formed. Compare the progression obtained with the arithmetical and exponential progressions previously studied.

#2 Mark off a square area in the classrooms to represent the environment. Inform the students that they are to represent population, and then direct one student to enter the square representing the environment. At fixed intervals, such as one minute, add students to the square area following an exponential progression. This is to simulate population growth. Inform students that no one in the area should be in contact with any other inhabitant of the square, and continue adding students until no more can enter

Discussion:

- Compare the time required to fill half of the square with that required to fill the whole area.

- What did students have to forfeit as more and more individuals entered the area?

- In actual cases of population increase, what other restrictions and deprivations are experienced by individuals?

The above activity is taken from Environmental Education Instructional Activities developed under the auspices of the Environmental Task Force in the New York State Education Department, p. 15.

#3 Discuss mitosis and fission as examples of exponential reproductive processes using audio-visual materials.

Possible resources*:

1. "Animal mitosis (first cleavage in Ascaris)" (Filmstrip) National Teaching Aids, 1965. 8 frames, color, 35mm.

2. "Genetics slides" (Slide set) Cleveland Health Museum and Education Center, 1970. 5 slides, color, 2x2 inches.

3. "Plant and Animal Mitosis" (Slide set) Harper & Row, 1973. 20 slides. color. 35 min

4. "Plant Mitosis" (Filmstrip) National Teaching Aids, 1967. 8 frames. color. 35

5. "Binary Fission" (Filmstrip) National Teaching Aids, 1965. 8 frames. color. 35 mm.

*All materials should be reviewed before using

LEARNING ACTIVITY #5: Investigating Population

Extract activities from:

Population. Grades 7-12. Environmental Education

Instructional Unit. Final Edition. Educational Resources Information Center, ED 092 377 Raleigh, North Carolina: North Carolina State Dept. of Public Instruction, 1973.

Unit #2 ....But the Environment has a say in the matter: Law of Scarcity and Law of Control

Behavioral Objectives:

Upon completion of this unit the student will be able to:

1. Compare and contrast in writing the law of supply and demand as it operates in a market economy with its operation in nature ecology.
2. State in writing the principle of scarcity.
3. State in writing the law of control.
4. List three limiting factors and for each factor briefly describe an example of its operation in nature which has been obtained through personal research or through a class discussion
5. Participate in one of the four projects in the Network of Interdisciplinary Activities and submit a lab report or other written assignment appropriate to the activity.
6. After having participated in one of the projects in the Network of Interdisciplinary Activities and the subsequent Class Presentations, write an essay in which he describes the relationship between the facts, ideas, and questions he obtained through his activity and those obtained through one of the other activity groups.

References:

1. Storer, J. H., The Web of Life, The New American Library, Inc., 1953, pp. 76-83.

2. McClary, Andrew, Biology and Society, MacMillan Publishing Co., Inc., 1975, pp. 114-116.

3. Reid, K., Lauwerys, J. A., Joffe, J., and Tucker A., Man, Nature and Ecology, Doubleday and Company, Inc. 1974, pp. 398, 16-17.

4. Farb, Peter and the Editors of Life, Ecology, Time, Inc., 1963, pp. 146-147.

5. Kormondy, E. J., Ed., Readings in Ecology, Prentice-Hall, Inc., 1965, pp. 106-109: "The Role of Weather in Determining the Distribution and Abundance of Animals: by L. C. Birch - 1957.

6. Kormondy, E. J., Concepts of Ecology, Prentice-Hall, Inc., 1969, pp. 62-69.

7. Odum, E. P., Ecology, Holt, Rinehart and Winston, Inc., 1963, pp. 90-93.

8. Sherman, I. W. and Sherman, V. G., Biology A Human Approach, New York Oxford University Press, 1975, pp. 504-515

LEARNING ACTIVITY #1: Some Economic Principles: The Market Economy vs. Nature AIM

Present to students the fundamentals of the Law of Supply and Demand as it operates in the market economy.

Have students compare and contrast the market relationship of supply and demand with the ecological relationship of these two phenomena.

Questions:

-Can nature meet all demands placed upon its resources?
-Which, if any, resources are of renewable supply? Which are non-renewable?
-Does man tend to approach nature in the same way that he approaches the market economy? Are there potential dangers inherent in such a view?

LEARNING ACTIVITY #2: Research Activity

Introduction:

- Why are the reproductive potential of organisms not fully realized? What is the check?
- Law of Scarcity: Students should be allowed to derive this principle based on Learning Activity #1:
- There exists a scarcity of natural resources, that is, the quantity available is small in comparison to needs and demands. This scarcity serves to limit population growth.
- Law of Control: Have students hypothesize this principle.
- There exist various environmental checks or safety valves which block the full realization of organisms' reproductive potentials. These checks are called limiting factors, and the law of scarcity demonstrates the factors of limited food supply and lack of space. Other factors: disease, predators and weather.

Have students do research on an organism of their choosing to determine:

1) The reproductive potential of the plant or animal.
2) The limiting factors which specifically block the full realization of this organism's reproductive potential.

The follow-up for this research endeavor should include class sharing and discussion of the especially important and interesting examples of limiting factors discovered by the students individually.

LEARNING ACTIVITY #3: Network of Interdisciplinary Activities AIM

Allow students to choose which of the following activities they will participate in:

#1 Social Studies: Ancient Civilization

Students investigate the decline of ancient civilizations.

For the purpose of this activity, special emphasis should be placed on the significance of any form of natural resource depletion or environmental deterioration which was a contributing economic factor to the civilizations decline.

- Speculate as to whether citizens at the time were aware of the potential problems that were being created by such actions, and whether willful disregard was the reason such actions were largely unchecked.

- Given any one of the illustrative studies by the students, did it seem that there were alternatives to these environmental malpractices?

- What reasons could possibly have been given for not selecting the alternatives?

#2 Social Studies: Current Events

Students collect newspaper and magazine clippings and pictures illustrating scarcity and factors causing scarcity in our society. Some suggested problems.

- The closing of beaches due to oil spills (limiting recreation)

- Fish mutations and depopulation in polluted waters (decreasing food supply)

- The closing of clam harvesting areas due to pollution (decreasing food supply)

- City smog (affecting health)

Questions:

1. What other necessities of life are becoming scarce as a result of environmental degradation?

2. Would nature replenish and cleanse itself if we were able to halt all forms of pollution immediately? How long would it take?

3. Since we cannot or will not halt these forces immediately, what does the immediate future hold for the environment?

#3 English Language Arts: Creative Writing

Students are asked to select one of the following quotations as a theme for a creative writing composition. Encourage the students to attempt figurative comparisons by using analogies and implementations in their comparisons. Students should include in their writing: time and place, description of existing conditions, the authors' perceptions and values, and analogies of specific environmental conditions (today).

- "There is nothing man cannot make natural; there is nothing he cannot lose."

Blaise Pascal

- "We used to be individuals, not populations. Perhaps we are now preparing for the great slaughter. No reason to be alarmed; stone dead is dead; breeding like rabbits we hasten to meet the day."

Robinson Jeffers

- "All things to each other
by almighty power
hidden linked are
That thou cans't not touch
a flower
Without troubling of a star"

Francis Thompson

- "Behold the turtle; he makes progress only when he sticks his neck out."

James B. Conant

- "For as long as man has dwelt upon this earth spring has been the season of rebirth and the singing of the birds. Now in some parts of America spring has been strangely silent, for many of the birds are dead."

Rachel Carson

- "We travel together, passengers on a little spaceship, dependent on its vulnerable reserves of air and soil; all committed for our safety to its security and peace; preserved from annihilation only by the care, the work, and the love we give our fragile craft."

Adlai Stevenson

Special Note:

It is strongly recommended that both the individual teacher and his students add to this list other applicable quotations which they have found.

#4 Physics: The Incandescent Bulb vs. the Flourescent Bulb

The two most popular methods of home illumination are the flourescent tube and the incandescent bulb. Using a fluorescent tube and an incandescent bulb of the same wattage, compare the intensity of illumination of each with a photoelectric device.

Questions:

1. Which type of bulb provides the greatest illumination for the amount of energy consumed per unit time (power)?

2. Which type of bulb is most widely used in business and industry? Why?

3. Which type of bulb is most widely used in home illumination? Why?

4. What are the disadvantages of the incandescent bulb?

5. What are the disadvantages of the fluorescent bulb?

6. What might some lamp designs look like that would use the flourescent bulbs yet retain some of the design characteristics of traditional home lighting fixtures?

7. Would serious considaration of such designs be appropriate action to the end of energy conservation? Why?

Class Presentations:

Provisions should be made for students to be able to share, at organized and established times, the creations, discoveries and results of their work. (Perhaps a few class periods could be set aside for this purpose.)

This will not only provide each student with additional information, but it will also make available to each student the benefits of an interdisciplinary outlook.

*Taken from: Living within our means: Energy and Scarcity, planned and developed by Barry W. Jamason, Chairman of the New York State Education Department's Environmental Task Force,pp 73; 18-19; 60.

** Taken from: Environmental Education Instructional Activities, planned and developed by Barry W. Jamason, pp. 15-16.

THE ECOSYSTEM GAME

Introduction

The purpose of this game is to simulate the phenomena that occur in ecosystem development. Thus, the game incorporates the following functions of an ecosystem.*

1) The capture and incorporation of energy from the sun;
2) The manufacture of organic materials by producers;
3) The ingestion of these materials and their assimilation by consumers;
4) The breakdown of organic materials by decomposers to produce simpler substances;
5) The changing of these simpler substances to forms which can be used by producers.

The game has been designed to specifically cover the last three modules of this learning activity package as well as to include material presented in earlier modules. The modules which constitute the conclusion of this package are:

Module V: The Organism-Organism Relationship

Topics: Populations, Communities, Competition, Territoriality, Interdependence

Module VI: The Ecosystem

Topics: Structure and Species Diversity, Ecosystem Functions, Climax, Progression and Homeostasis.

Module VII: Man and Ecology

Man holds a unique position with respect to ecology. Although he is subject to the same natural forces that operate on all other organisms, he alone is able to alter his environment through conscious planning.

The game board is included here in separate pieces, much like those of a jigsaw puzzle. To facilitate the construction of the game board a small scale sample has been provided.

References:

1. Turk, Amos, and others, Environmental Science, W. B. Saunders Co., 1974
2. McClary, Andrew, Biology and Society, MacMillan Publishing Co., Inc., 1975
3. Storer, J.H., The Web of Life, The New American Library, Inc., 1953
4. Clarke, G.L., Elements of Ecology, John Wiley & Sons, Inc., 1954
5. Watt, K.E.F., Principles of Environmental Science, McGraw-Hill Book Company, 1973.
6. Russell, H.R., Earth, The Great Recycler, Thomas Nelson,Inc., 1973
7. Carpenter, R.L., Microbiology, W. B. Saunders Co., 1972
8. Odum, E.P., Fundamentals of Ecology, W. B. Saunders Co., 1959

*Clarke, G.L. Elements of Ecology, John Wiley & Sons, Inc. 1954

RULES OF THE GAME

Introduction:

The ecosystem is the basic unit of ecological structure and function, that is, it is the site within which all other concepts and elements of ecology interact. It is composed of a community of organisms, plants and animals living together in a given area, along with the environmental region they inhabit.

1. There are 4 players each assigned a representative marker (for example, 4 colored discs can be used.)

   Each player throughout the game will own 1 or more populations of organisms, that is, groups of individuals of any one kind of organism. The population(s) represented will perform one of the following ecological roles:

   Producer - organisms which are able to make their food from inorganic materials by making use of energy from the sun.

   Herbivore, or Primary Consumer - an organism which feeds upon producer organisms.

   Carnivore, or Secondary Consumer - an organism that consumes herbivores.

   Decomposer - an organism, which as a bacterium or fungus, that feeds upon dead organic matter by breaking it down into simpler materials some of which are released and may then be used by producers.

   The ecosystem contains 5 producer populations, 5 decomposer populations, 4 herbivore populations, and 4 carnivore populations. Each population has 20 members available for ownership by a player. Stacks of poker chips can be used to represent members of populations.

2. At the start of the game each player will be given a principal population consisting of 10 members along with 5 members of each of the other types of populations.

   To begin the game, each player rolls the pair of dice to determine which population type will be established as his principal population. The player who rolls the highest number receives a producer population as his principal population, while the next highest receives a herbivore population, the next highest receives carnivore population, and finally, the remaining player receives a decomposer population.

   This table indicates each players holdings at the start of the game.

	Producers	Herbivores	Carnivores	Decomposers
Player #1	10*	5	5	5
Player #2	5	10*	5	5
Player #3	5	5	10*	5
Player #4	5	5	5	10*

*Principal Population

3. The functioning of the ecosystem first requires the capture of the sun's energy and its transformation into chemical energy. Therefore, the first player is the player possessing the producers as his principal population. Following the order of food chain relationships, the second player owns herbivores as his principal population, the third holds carnivors, and the last player owns decomposers as his main population.

Each player rolls the dice in turn and moves the number of spaces indicated by the number rolled.

4. The Most Fundamental Rule:
THE PRINCIPLE OF INTERDEPENDENCE

No organism can exist in isolation of all other organisms: organisms depend on each other for food and other necessities so that they exist in a state of mutual reliance.

This concept can be visualized as an Ecosystem Domino Effect. Given a complex arrangement of dominos, the tapping of one domino sets into motion the progressive toppling of each domino in the complex. By the initial action, a self-sustaining progression of events is begun. (It might be helpful to demonstrate this concept by having one or more students prepare a domino presentation.)

Because of interdependence, many game directions involve more than one population.

5. When a player lands on a space labelled, Man-Caused Event or Natural Event, he draws a card from the appropriate stack of cards, follows the directions it contains, and then returns the card to the bottom of the pile.

If the directions apply to a population type which the player does not own or which has attained a stable state (see Rule #9) he simply returns the card to the bottom of the stack.

If the directions apply to more than onepopulation type, the player follows those that apply to the non-stable populations he owns.

6. Predator-Prey Squares

When one player lands on a predator-prey space, he assumes the role of predator, and all other players that land on that space while he is on it assume the prey role.

The predator gains members at the expense of the prey according to one of the following two predator-prey couplets. The predator must state the proper couplet he is employing.

Predator	Prey	Prey forfeits to Predator
Herbivore	Producer	2 Members
Carnivore	Herbivore	2 Members

7. The following population interactions are incorporated into the game as Natural Events:

1) Mutualism
2) Parasitism
3) Competition
4) Neutralism
5) Commensalism
6) Amensalism
7) Protocooperation

These species interactions are not fixed, but rather can change within the lifetime or organisms due to changes in the environment or in developmental stages of the organisms. The account for this fact all of these relationships are written on Natural Event Cards. They are to be used by the player who acquires them to counteract a Predator-Prey relationship should one arise. The card can be used only if its owner is on a Predator-Prey space, and it can be used only once.

After the card has been used it must be returned to the bottom of the stack of Natural Event Cards. If it is acquired again during the game, its owner may again use the card following the rules stated above.

8. Food Chain Spaces (#32, 35, 38, 40)

If a person who possesses a non-stable decomposer population rolls the dice and would land on space #32, #35, or #38, he may choose instead to go directly to space #40 and collect 3 members.

If he chooses instead to land on the space indicated by the dice, he forfeits the option to detour to space #40 until he has once again travelled the game board.

9. Climax

The winner of the game is obtained through the application of the principles of Progression and Homeostasis:

Through time, all ecosystems tend toward maturity and greater complexity. The simpler life forms of early stages are followed by higher forms and the early conditions of excess potential energy and high energy flow per unit of biomass give way to the more efficient use of energy.

The complexity of the ecosystem is determined by the diversity of species it contains: the greater the variety of specieis, the more complex the ecosystem.

This progression of the ecosystem is toward a stable equilibrium, a state of homeostasis governed by self-maintenance and self-regulation.

To simulate this characteristic development of an ecosystem, the winner of the game is the first player to obtain at least 15 members of his principal population and 10 members of each of the other three population types. A player's principal

population once it has at least 15 members in it is considered a stable population, and it no longer enters into the activities of the game but rather it is left undisturbed. In the same way the other three population types once each contains at least 10 members, are considered stable populations, and once they are established as stable they do not again function in the game. Thus, the winner of the game possesses at least 4 stable populations.*

* To hasten the game, play may be stopped after a fixed period of time and the winner may then be considered as the person having each of the 4 population types represented and having the largest total ecosystem members.

NATURAL EVENTS

The following is a list of statements which should be typed or printed on index cards which are to be randomly placed in a pile on the game board.

1. Through mutation and natural selection a group of organisms is now so different from its early ancestors that it constitutes a separate species.

   Collect three members of any population.

2. In the course of succession, one population has been eliminated due to unfavorable environmental conditions created by a different population.

   Add two members to largest population owned; forfeit smallest population owned.

3. Due to an adaptation acquired, populations are able to withstand dry conditions.

   (You may retain this card until an opportunity arises in which you can use it).

4. In the course of succession, the ecosystem has become more suitable to your opponents' populations than to yours.

   Lose one member of each of your populations.

   East of your opponents gains one member to any one of their populations.

5. A lake has completed the natural process of eutrophication and has ceased to exist.

   Forfeit smallest population owned. If player owns card granting resistance to dry conditions population is unaffected.

6. Optimal environmental conditions have fostered multiplication of smallest population owned.

   Add members to this population to make it a stable one.

7. Limiting factor: Overpopulation has led to rapid spread of disease.

   Largest population owned loses six members.

8. Conditions of the environment have so developed so as to lead to a dormant stage in one of your populations.

   Isolate one of your populations. For your next three turns, this population does not enter into the game.

9. Population has entered a new niche and thrives.

   Add three members to a population owned.

10. Limiting factor: Populations have grown to the extent that water resources are being depleted.

Lose smallest population owned. If player owns card granting resistance to dry conditions, population is unaffected.

11. Scarcity of resources:

Reduce each population owned by one member.

12. Mutualism: Two interacting species benefit, and neither species can survive without the other. You may retain this card for future use in the event of a Predator-Prey encounter. In such a case, substitute these directions for those of the Predator-Prey relationship.

Both players add 2 members to any one of their populations.

13. Parasitism: One species is dependent upon another and through its interaction with it, harms the other species. You may retain this card for future use in the event of a Predator-Prey encounter. In such a case, substitute these directions for those of the Predator-Prey relationship.

Card owner: add four members to any one population.
Opponent: lose three members from population specified by card owner.

14. Competition: Two interacting species affect each other negatively by struggling for the satisfaction of a common need.

You may retain this card for future use in the event of a Predator-Prey encounter. In such a case, substitute these directions for those of the Predator-Prey relationship.

Both players lose two members from any one of their populations.

15. Neutralism: Two species affect each other in no way. You may retain this card for future use in the event of a Predator-Prey encounter. In such a case, substitute these directions for those of the Predator-Prey relationship.

Populations of both players remain unchanged.

16. Commensalism: Interaction in which one species benefits, but the other remains unharmed. You may retain this card for future use in the event of a Predator-Prey encounter. In such a case, substitute these directions for those of the Predator-Prey relationship.

Card owner adds three members to one population owned.

17. Amensalism: Interaction in which one species is harmed, but the other species remains unaffected. You may retain this card for future use in the event of a Predator-Prey encounter. In such a case, substitute these directions for those of the Predator-Prey relationship.

Owner of card maintains unchanged population.

Opponent loses three members of one population owned.

18. Protocooperation: Both of the interacting species benefit, but the relationship is not essential to the survival of either species. You may retain this card for future use in the event of a Predator-Prey encounter. In such a case, substitute these directions for those of the Predator-Prey relationship.

Both players advance three spaces.

19. Hurricane hits area.

Each population owned loses four members.

20. Strong winds harm plant life.

Producer populations owned lose three members.

Due to destruction of food and shelter, herbivore populations lose two members.

Decomposers thrive: decomposer populations add three members.

MAN-CAUSED EVENTS

The following is a list of statements which should be typed or printed on index cards which are to be randomly placed in a pile on the game board.

1. A monoculture has been created by a farmer. The crop being cultivated proves to be a valuable food source for primary consumers, and their feeding destroys the crop.

   Add three members to herbivore populations owned.

2. A careless human being starts a forest fire by discarding a cigarette.

   Producer populations each lose five members; all consumer populations lose four members both directly by fire and indirectly by loss of food and shelter.

3. Insect pests have acquired resistance to DDT and have begun attack on vegetation.

   Producer population loses three members.

4. In an effort to maintain the existence of an endangered carnivore species, man has established a reserve.

   The animals reproduce. Add two members to a carnivore population.

5. A densely populated nation is exhausting its food supply. Scarcity of resources reaches dangerous proportion.

   Reduce a producer population by three members.

6. Man has developed new farm equipment that greatly increases crop production.

   Add six members to a producer population.

7. Hunters have brought about the extinction of a carnovore species.

   Forfeit smallest carnivore population.

8. Thermal pollution of a river is adversely affecting fish populations.

   Secondary consumer populations lose two members.

9. Cultural eutrophication: Man's organic wastes, sewage, is being dumped into a lake. The nitrogen phosphorus and other compounds in the dewage have led to algal population explosion followed by much decomposer activity which has depleted oxygen.

   Add four members to decomposer populations; reduce consumer populations by three members.

10. Man has imported a herbivore species valued for its flesh and fur. Abundant food and absence of natural predators has led to species' population explosion, at the expense of vegetation.

    Add four members to a herbivore population; forfeit three members of a producer population.

11. A chlorinated hydrocarbon poison which was used at some time in the past to destroy an insect pest has, over several years, accumulated in each stage of the food chain. Finally, a toxic concentration has been reached in a carnivore population.

    Forfeit three members of a carnivore population.

12. Drought would have caused the death of many organisms, but man has made water available from boreholes and drinking tanks reserved for such emergencies.

    All populations remain unharmed.

13. A flood has threatened many animal species, but man has embarked upon a rescue effort consisting of the translocation of stranded animals to safe reserves.

    Minimal numbers have been lost: forfeit one member of each herbivore and carnivore species.

14. Inert wastes discarded by man have piled up, but due to regenerative powers, new ecosystems have established themselves around the waste.

    Populations are unchanged.

15. Man has unknowingly imported an insect pest that has attacked acres of crops.

    A producer population loses three members.

16. Man has practiced effective pollution control.

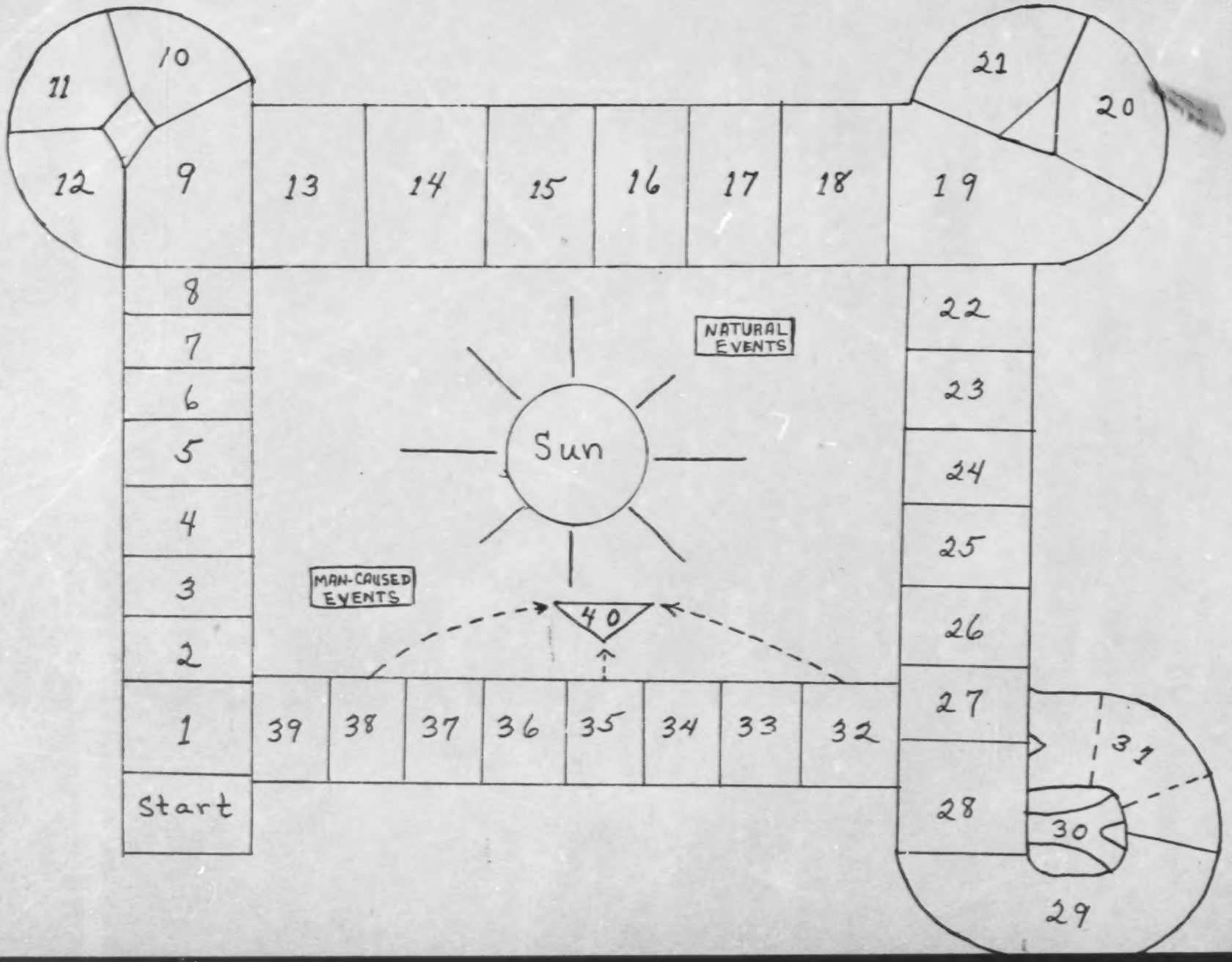
    All populations are undisturbed.

17. Man has restored a forest area that was destroyed by fire.

    Collect two producer organisms.

18. A synergistic reaction: organic pollutants and metallic mercury have been introduced into a lake. Bacterial populations thrive due to organic pollutants and convert the metallic mercury into methyl mercury which is absorbed by fish and subsequent members of the food chain.

    Lose three members of each carnivore population.


Start
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Sun
NATURAL EVENTS
MAN-CAUSED EVENTS

Carnivores Add
2 Members

4

Predator - Prey
Interaction

3 Conditions Poor for Photosynthesis

Producers Lose 3 members

Herbivores Lose 2 Members

Decomposers Add 3 Members

2 Stable Rate of Photosynthesis

Producers Stable

Decomposers Lose
2 Members

1 Conditions Suitable for High Rate of Photosynthesis

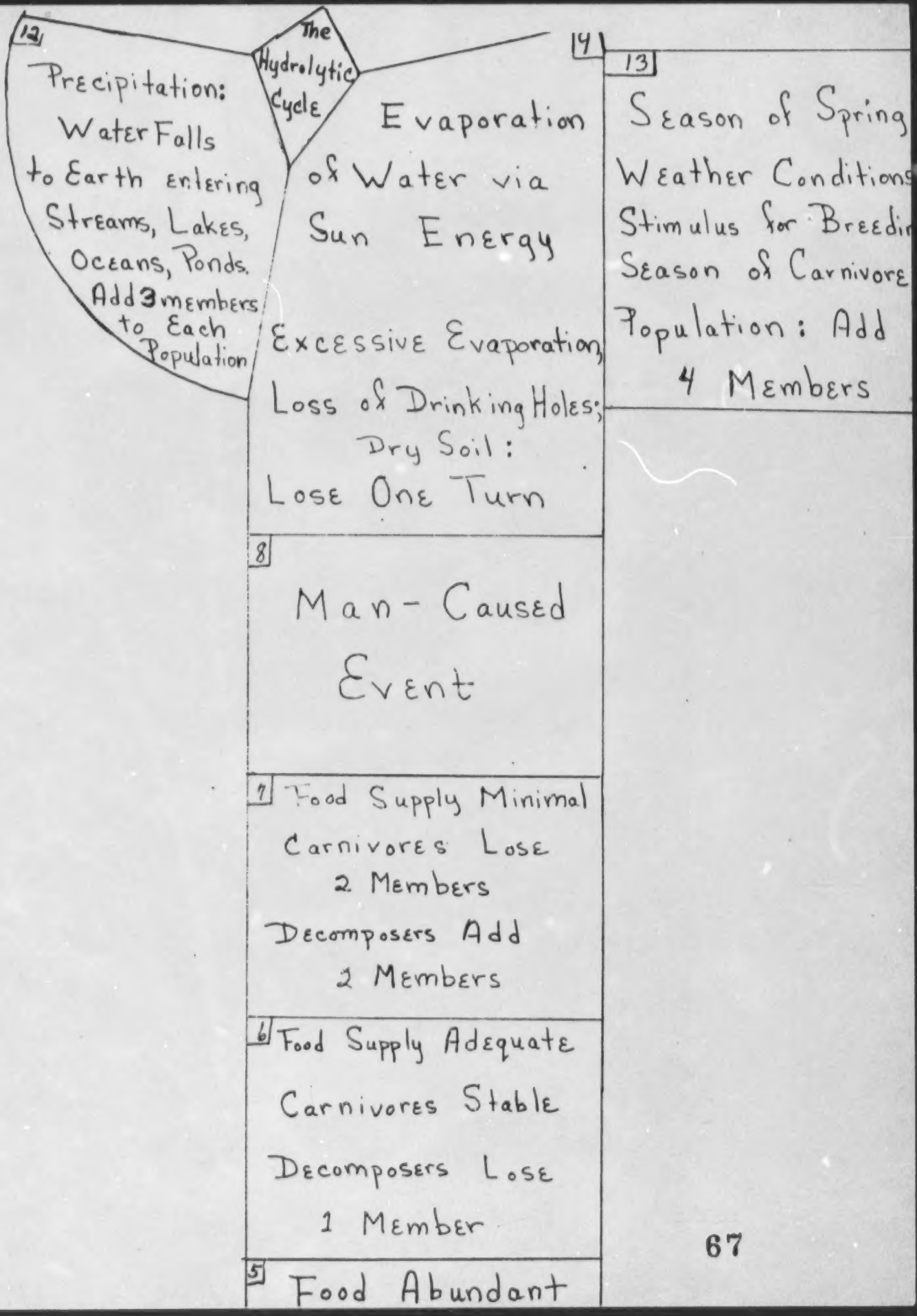
Producers Add 3 Members

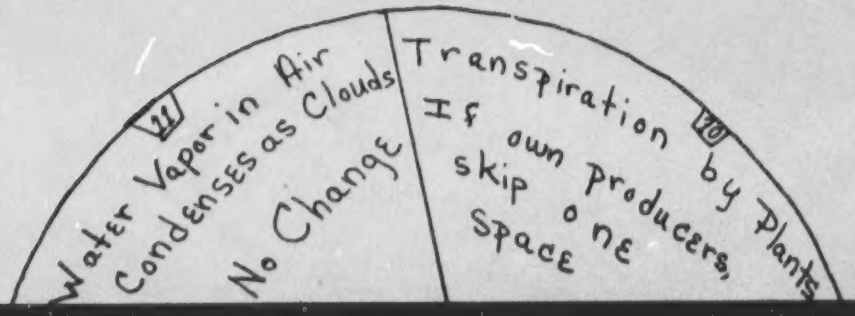
Herbivores Add 3 Members

START
by
Principal Producer

39 Established Territory of Herbivore Family. Invasion by a Non-family Member Results in Conflict. Herbivore Population Loses 1 Member

38 E C S A


12
The Hydrolytic Cycle
Precipitation: Water Falls to Earth entering Streams, Lakes, Oceans, Ponds. Add 3 members to Each Population
14
Evaporation of Water via Sun Energy
Excessive Evaporation, Loss of Drinking Holes; Dry Soil: Lose One Turn
13
Season of Spring Weather Conditions Stimulus for Breedi
Season of Carnivore
Population: Add 4 Members
8
Man-Caused Event
7
Food Supply Minimal
Carnivores Lose 2 Members
Decomposers Add 2 Members
6
Food Supply Adequate
Carnivores Stable
Decomposers Lose 1 Member
5
Food Abundant

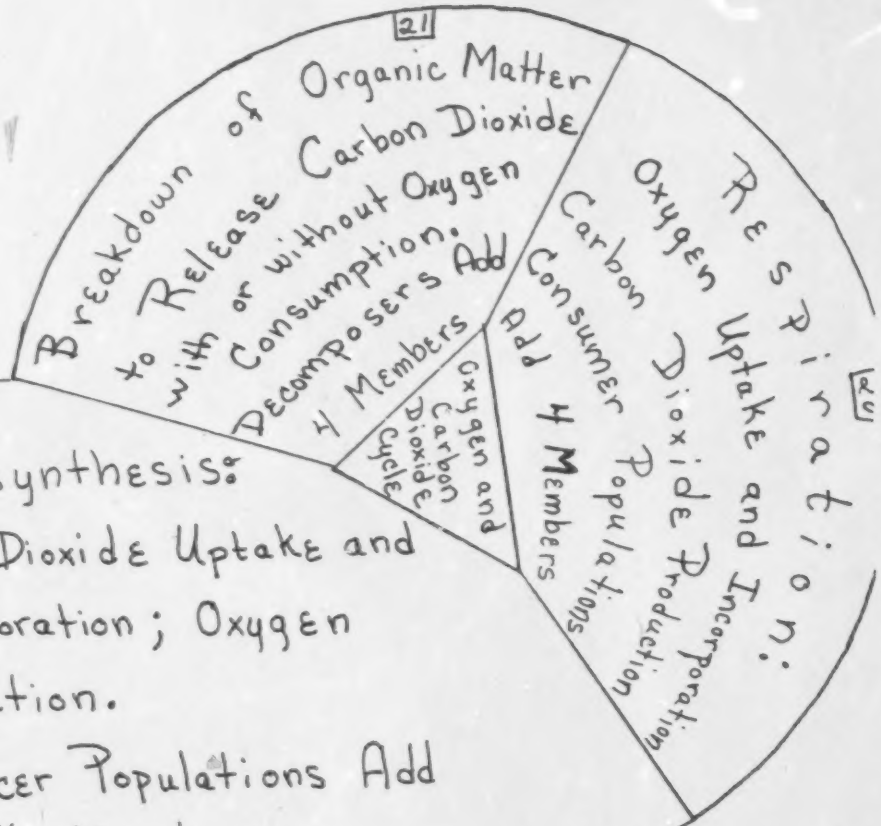

11
Water Vapor in Air Condenses as Clouds
No Change
10
Transpiration by Plants
If own producers, skip one Space

14	15	16	17
Predator-Prey Interaction	Season of Summer Long Periods of Intense Sun and Lack of Rain Vegetation and Animals Dying: Producers, Herbivores and Carnivores Lose 2 Members	Season of Autumn Abundant Dead Organic Matter Decomposers Thrive: Add 4 Members	Season of Extreme Abundant Life Process In Some Population Unc

Winter Cold; Snowfall es Slowed; Cases, Dormancy Numbers hanged

18 Natural Event

19 Photosynthesis: Carbon Dioxide Uptake and Incorporation; Oxygen Production. Producer Populations Add 4 Members.


21
Breakdown of Organic Matter to Release Carbon Dioxide with or without Oxygen Consumption. Decomposers Add 4 Members
Oxygen Carbon Dioxide Cycle
Carbon Consumer Populations Add 4 Members
Oxygen Uptake and Incorporation; Carbon Dioxide Production
Respiration:
20

22 Beneficial Genetic Adaptation

Add 2 Members to Any One Population

23

Predator-Prey Interaction

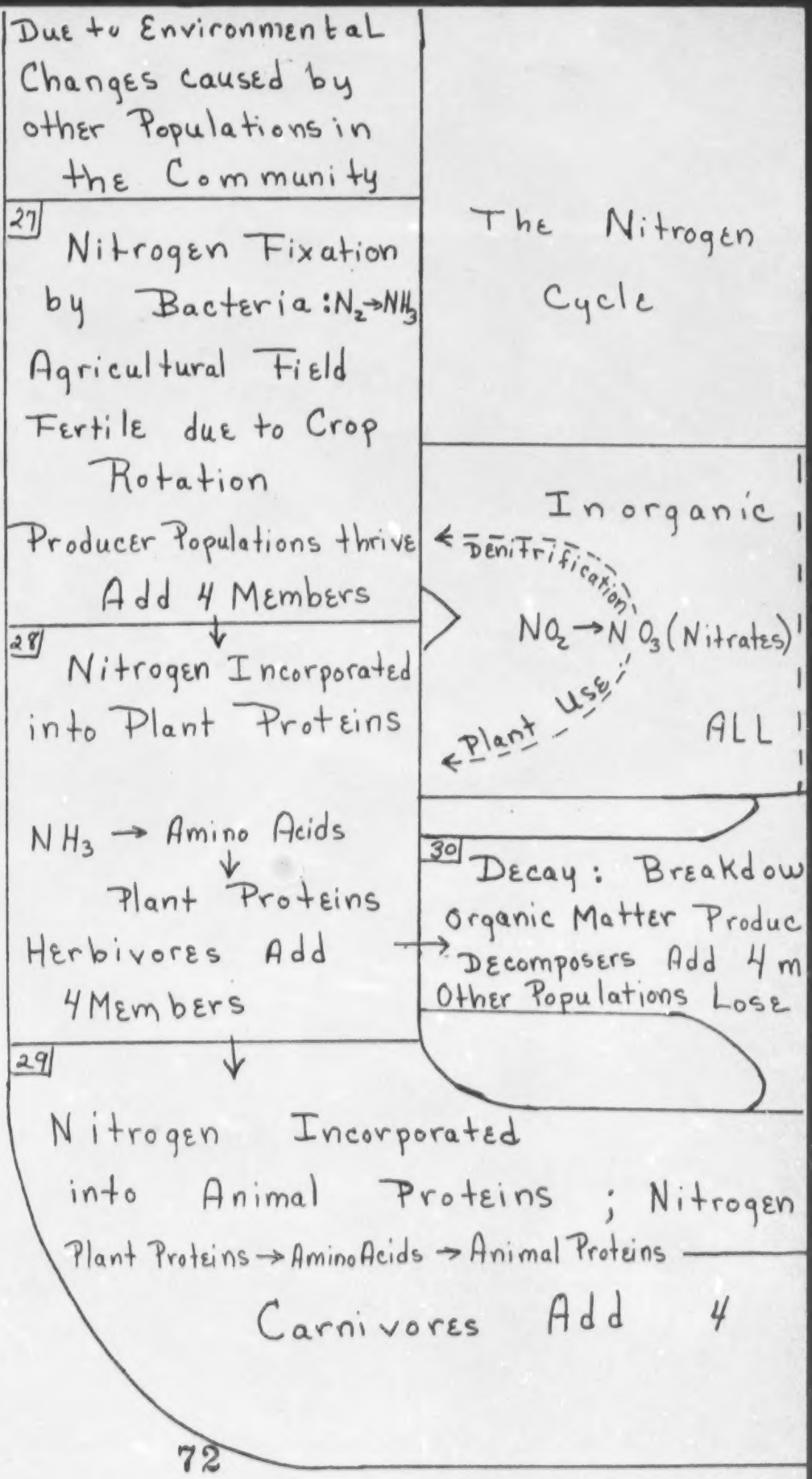
24 Failure of Population to Adapt to Drastic Environmental Change Results in Extinction: Lose Smallest Population Owned

25

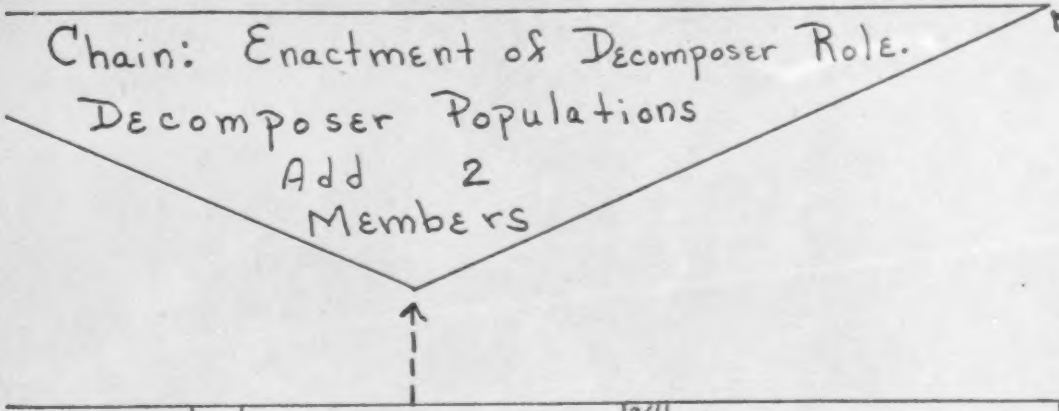
Man-Caused Event

26 Succession: Lose a Herbivore Population

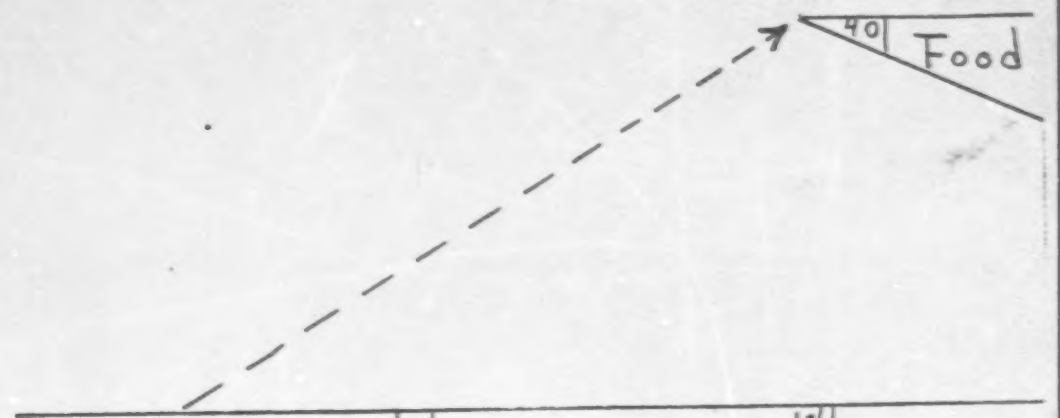
Square #26 is completed on next page.


Due to Environmental Changes caused by other Populations in the Community
The Nitrogen Cycle
27
Nitrogen Fixation by Bacteria: $N_2 \rightarrow NH_3$
Agricultural Field Fertile due to Crop Rotation
Producer Populations thrive
Add 4 Members
Inorganic
Denitrification
$NO_2 \rightarrow NO_3$ (Nitrates)
Plant Use
ALL
28
Nitrogen Incorporated into Plant Proteins
$NH_3 \rightarrow$ Amino Acids
Plant Proteins
Herbivores Add 4 Members
30
Decay: Breakdow
Organic Matter Produc
Decomposers Add 4 m
Other Populations Lose
29
Nitrogen Incorporated into Animal Proteins; Nitrogen
Plant Proteins → Amino Acids → Animal Proteins
Carnivores Add 4

Phenomena
Bacteria
Members
Urea (Nitrogenous Waste)
Lost in Urea Wastes
2 members
ing NH3
n of
Maintained
Urea → NH3
Populations
NH3 → NO2 (Nitrites)
Vio-
31

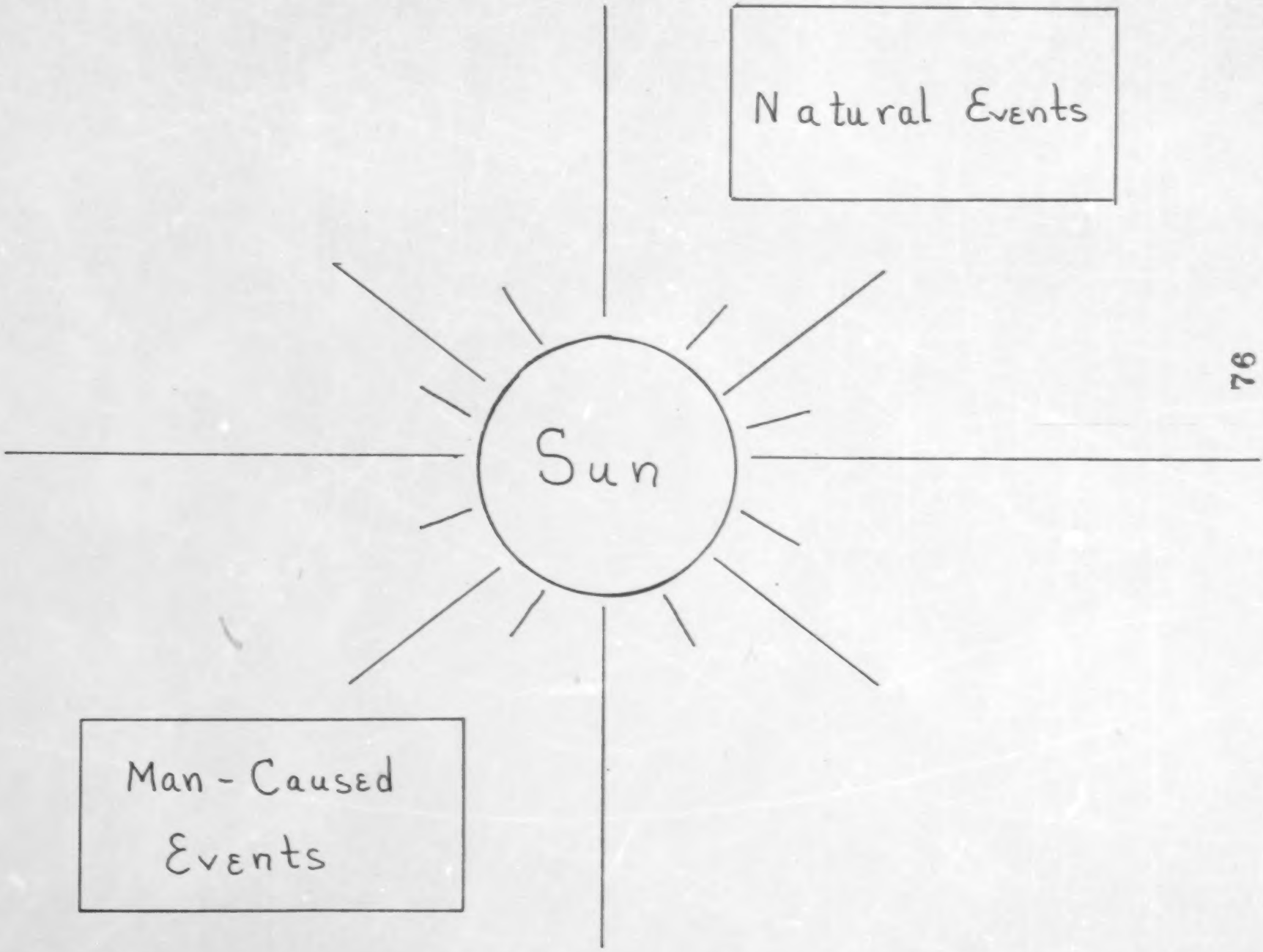


Community: Animals mon Habitat tually sted ε in ations	35 Food Chain: Enactment of Herbivore Role. Primary Consumer Populations Add 2 Members	34 Established Territory of Carnivore Family. Invasion by a Non-family Member Results in Conflict. Carnivore Population Loses 1 Member	33 Predator-Prey Interaction	32 Food Chain: Enactment of Producer Role. Producer Populations Add 4 Members



Food Chain: nactment of arnivore Role. Econdary Consumer Populations dd 2 Members	37 Natural Event	36 Functioning Plants and Sharing Com are Mu Adju No Chang Popul

Square # 38 is completed on first page.


Natural Events
Sun
Man-Caused Events

AIM ENTRIES

1. Module #2
   Unit #2
   Learning Activity #2: Network of Lab Investigations

2. Module #3
   Unit #2
   Learning Activity #1: Team Teaching

3. Module #4
   Sequence A
   Unit #2
   Learning Activity #1: Realia/Demonstration Network:
   Provide several semonstrations of organisms affecting
   their environments.

4. Module #4
   Sequence B
   Unit #1
   Learning Activity #3: Team Teaching

5. Module #4
   Sequence B
   Unit #2
   Learning Activity #1: Team Teaching

6. Module #4
   Sequence B
   Unit #2
   Learning Activity #3: Team Teaching

GLOSSARY*

Autotroph (primary producer) An organism that synthesizes organic compounds from inorganic ones (such as water, carbon dioxide, and salts) with the aid of an external supply of energy. The energy comes either from light (in photosynthesis) or from the breakdown of inorganic substances (in chemotrophs). Includes some bacteria, algae, and green plants.

Carnivore (secondary consumer) An organism that feeds on herbivores (primary consumers): for instance, a lion that feeds on a zebra.

Climax The stable end-product of succession, consisting of plants and animals in equilibrium with each other and with the environment. Unless some factor in the ecological conditions changes, a climax association is capable of existing indefinitely.

Commensalism An association between two or more individuals of different species from which one derives feeding, or other, benefits without significantly affecting the other.

Community The populations of different species, plant and animal, within a given area.

Decomposers Organisms that feed on dead plant and animal material, by breaking it down physically and chemically.

Denitrification The breaking down of nitrogenous compounds by bacteria with the release of free nitrogen to the atmosphere.

Ecology The study of animals and plants and the interrelations between them, considered in relation to their nonliving environment; the study of ecosystems and biomes.

Ecosystem All the communities in a given area considered together with their nonliving environment. In general, an ecosystem is a reasonably recognizable area, although adjacent ecosystems can overlap.

Epilimnion The top, warm layer of water in freshwater lakes during summer.

Food Chain A linear chain of organisms in which each link in the chain feeds on the one before and is eaten by the one after. At the start of the chain are the primary producers; at the end, the carnivores.

Food Web All the interrelated food chains in an ecosystem. The sum total of all the feeding habits of all the organisms in an ecosystem.

Gene Pool All the genes in a population of a species, which, through potential interbreeding of the members of the population, are available to produce a new generation.

Habitat The home of an organism.

Herbivore (primary consumer) An organism that feeds on primary producers (autotrophs.)

Heterotroph (consumer) An organism that obtains its organic food from other organisms. All animals, some fungi, and most bacteria are heterotrophs.

Hydrosphere The water on the surface of the Earth.

Hypolimnion The cold bottom layer of water in freshwater lakes.

Limiting Factor A factor of the abiotic environment that limits optimum growth because it is in short supply.

Monoculture A farming system based on a single crop, grown year after year.

Mutualism In this book, mutualism means a close relationship between individuals of two or more species for their mutual benefit.

Niche The habitat of an organism and the role it plays in the ecosystem.

Omnivore An animal that eats many kinds of food, both plant and animal.

Parasite An organism that makes, at some stage in its life history, some connection with the tissues of an individual of a different species, from which it derives food. The parasite may harm the host to a greater or lesser extent but does not usually kill it.

Photosynthesis The production of organic compounds, such as glucose from carbon dioxide and water, liberating oxygen. The energy required for this reason is obtained from light, with the aid of the green pigment chlorophyll.

Population A group of individuals of the same species living in a given area.

Precipitation Rain, hail, and snow.

Predator An animal that kills other animals for its food.

Prey Animals killed and eaten by predators.

Primary Consumer see Herbivore.

Primary Producer see Autotroph.

Respiration (cellular or internal) The chemical reactions by which an organism obtains energy from organic compounds. Aerobic respiration requires oxygen. Anaerobic respiration does not.

Secondary Consumer see Carnivore.

Succession The replacement of one community by another. The progressive change in the composition of a plant community, and hence the animal one, during the development of vegetation.

Symbiosis An association of individuals of two or more species living together for all or part of their lives. Includes Commensalism, mutualism and parasitism.

Territory An area of ground within which an animal is master over others of the same species.

Thermocline The layer of water of rapidly changing temperature in lake water in summer.

Transpiration The loss of water vapor from a plant. It occurs mostly through the stomata of the leaves.

Weathering The action of rain, snow, frost, ice, wind, sunshine, and so on on rocks, altering their form, colour, texture, and composition.

*All definitions are taken from:
Man, Nature and Ecology, Reid, Deith and others, Doubleday and Company, Inc., 1974.